



# THE BRITISH JOURNAL OF SURGERY

UNDER THE DIRECTION OF THE FOLLOWING EDITORIAL COMMITTEE

\* GEORGE E. GASK (London), *Chairman*

R. C. ALEXANDER (St. Andrews)  
F. J. ANDERSON (Calcutta)  
EDWARD ARCHIBALD (Montreal)  
SIR C. ARTHUR BALL, Bart. (Dublin)  
J. BEATTIE (London)  
GORDON BELL (Dunedin)  
P. B. BHARUCHA (Lahore)  
WILLIAM H. BOWEN (Cambridge)  
I. W. BREBNER (Johannesburg)  
RUSSELL C. BROCK (London)  
\*L. R. BROSTER (London)  
\*HUGH CAIRNS (Oxford)  
SIR E. ROCK CARLING (London)  
ZACHARY COPE (London)  
M. M. CRUICKSHANK (Madras)  
P. T. CRYMBLE (Belfast)  
\*COL. ELLIOTT CUTLER (U.S.A.)  
HAROLD R. DEW (Sydney)  
ERNEST FINCH (Sheffield)  
E. R. FLINT (Leeds)  
C. H. S. FRANKAU (London)  
W. B. GABRIEL (London)  
GEOFFREY HADFIELD (London)  
SURGEON CAPTAIN R. W. HIGGINS (Naval Medical Service)  
C. F. W. ILLINGWORTH (Glasgow)  
GEOFFREY JEFFERSON (Manchester)  
T. P. KILNER (London)

J. R. LEARMONTH (Edinburgh)  
L. C. E. LINDON (Adelaide)  
AIR COMMODORE P. C. LIVINGSTON (Royal Air Force Medical Branch)  
ADAMS A. McCONNELL (Dublin)  
A. D. MARSTON (London)  
\*E. K. MARTIN (London)  
B. C. MAYBURY (London)  
PHILIP MITCHINER (London)  
MAJ-GEN. D. C. MONRO (Army Medical Service)  
J. T. MORRISON (Liverpool)  
SIR ALAN NEWTON (Melbourne)  
W. H. OGILVIE (London)  
MILROY PAUL (Colombo)  
R. S. PILCHER (London)  
HARRY PLATT (Manchester)  
F. C. PYBUS (Newcastle-on-Tyne)  
\*E. W. RICHES (London)  
LAMBERT ROGERS (Cardiff)  
\*J. PATERSON ROSS (London)  
CHAS. F. M. SAINT (Cape Town)  
H. J. SEDDON (Oxford)  
\*G. GREY TURNER (London)  
SIR JAMES WALTON (London)  
BERNARD J. WARD (Birmingham)  
R. OGIER WARD (London)  
W. C. WILSON (Aberdeen)  
DAVID STORER WYLIE (Palmerston North, N.Z.)

\* CECIL P. G. WAKELEY (London), *Editorial Secretary*

\* Constitute the Executive Committee

---

## VOLUME XXXII

July, 1944, to April, 1945.

Nos. 125 to 128.

---

BRISTOL: JOHN WRIGHT & SONS LTD.

LONDON: SIMPKIN MARSHALL (1941) LTD., 12 OLD BAILEY, E.C. 4

WHOLESALE DISTRIBUTORS: WM. DAWSON & SONS LTD  
43 WEYMOUTH STREET, LONDON, W.1

TORONTO: THE MACMILLAN CO. OF CANADA LTD.

CALCUTTA: BUTTERWORTH AND CO. (INDIA) LTD.; THACKER, SPINK AND CO.

BOMBAY: W. THACKER AND CO.

SYDNEY: ANGUS AND ROBERTSON LTD. NEW ZEALAND: WHITCOMBE AND TOMES LTD.

UNITED STATES OF AMERICA: THE WILLIAMS AND WILKINS COMPANY, BALTIMORE, *Sole Agents*



PRINTED IN GREAT BRITAIN BY  
JOHN WRIGHT AND SONS LTD,  
BRISTOL

# CONTENTS OF VOLUME XXXII

	NUMBER 125	PAGE
THE EFFECT OF LIGATION ON INFECTION OF THE PATENT DUCTUS ARTERIOSUS	<i>Oswald S. Tubbs</i>	1
WAR SURGERY IN THE ROYAL AIR FORCE - - - - -	<i>Stanford Cade</i>	12
THE TREATMENT OF BURNS AND WOUNDS WITH SKIN LOSS BY THE ENVELOPE METHOD	<i>R. P. Osborne</i>	24
THE DIAGNOSIS OF THE DEPTH OF SKIN DESTRUCTION IN BURNS AND ITS BEARING ON TREATMENT	<i>David H. Patey and R. W. Scarff</i>	32
RECENT ADVANCES IN THE TREATMENT OF CARCINOMA OF THE MOUTH AND JAWS	<i>T. H. Somervell</i>	35
INJURIES OF THE URINARY BLADDER - - - - -	<i>J. Cosbie Ross</i>	44
INTRAPERITONEAL CHEMOTHERAPY - - - - -	<i>R. H. Gardiner</i>	49
SHOCK: A CONSIDERATION OF ITS NATURE AND TREATMENT - -	<i>J. E. Dunphy</i>	66
CHOLESTEATOMA OF THE PETROUS BONE - - - - -	<i>Joe Pennybacker</i>	75
ADRENAL NEUROBLASTOMA - - - - -	<i>T. A. Ogilvie</i>	78
LOCAL SULPHANILAMIDE TREATMENT OF FRESH WOUNDS IN COMPLETE PLASTERS	<i>J. Orr-Ewing, J. C. Scott, F. H. Masina, J. Trueta, and A. D. Gardner</i>	83
MINIATURE SCAR-CARCINOMA OF THE LUNG AND THE "UPPER SULCUS TUMOUR" OF PANCOAST	<i>Iltyd James and Walter Pagel</i>	85
ADRENAL VIRILISM: THE REPORT OF A CASE WITH UNUSUAL FEATURES -	<i>N. G. B. McLetchie</i>	90
SHORT NOTES OF RARE OR OBSCURE CASES - - - - -		100
REVIEWS AND NOTICES OF BOOKS - - - - -		107
SPECIAL PENICILLIN ISSUE		
EDITORIAL - - - - -		109
FOREWORD: ARMY PROGRESS WITH PENICILLIN - - -	<i>Major-Gen. L. T. Poole, D.S.O., M.C.</i>	110
THE PRINCIPLES OF PENICILLIN TREATMENT - - -	<i>H. W. Florey and M. A. Jennings</i>	112
BACTERIOLOGICAL METHODS IN CONNEXION WITH PENICILLIN TREATMENT	<i>L. P. Garrod and N. G. Heatley</i>	117
APPLICATION OF PENICILLIN TO WAR WOUNDS - - -	<i>Lt.-Col. J. S. Jeffrey</i>	124
THE BACTERIOLOGICAL EXAMINATION OF WOUNDS TREATED WITH PENICILLIN	<i>Major Scott Thomson</i>	129
THE TREATMENT OF FLESH WOUNDS BY EARLY SECONDARY SUTURE AND PENICILLIN.	<i>Lt.-Col. F. H. Bentley</i>	132
EARLY CLOSURE OF SOFT-TISSUE WOUNDS WITH CHEMOTHERAPEUTIC AGENTS	<i>Lt.-Col. James J. Mason Brown</i>	140
BATTLE CASUALTY FRACTURES IN ITALY - - - - -	<i>Lt.-Col. J. S. Jeffrey</i>	144
ON THE USE OF PENICILLIN TO CONTROL INFECTION IN OPEN FRACTURES OF THE FEMUR	<i>Major Ronald Furlong and Major John M. P. Clark</i>	147
BATTLE CASUALTY FRACTURES OF THE FEMUR: TREATMENT WITH PENICILLIN	<i>Major R. J. B. McEwan and Capt. J. G. Bickerton</i>	154
GAS GANGRENE IN ITALY - - - - -	<i>Lt.-Col. J. S. Jeffrey and Major Scott Thomson</i>	159

	PAGE
TREATMENT OF CLOSTRIDIAL INFECTIONS WITH PENICILLIN <i>Col. Elliott C. Cutler and Major William R. Sandusky</i>	168
INTRAPLEURAL PENICILLIN IN PENETRATING WOUNDS OF THE CHEST <i>Major W. F. Nicholson and Capt. C. R. Stevenson</i>	176
PENICILLIN IN THE TREATMENT OF WAR WOUNDS OF THE CHEST <i>Lt.-Col. A. L. d'Abreu, Major J. W. Litchfield, and Major Scott Thomson</i>	179
PENICILLIN IN HEAD AND SPINAL WOUNDS - - - - <i>Brigadier Hugh Cairns</i>	199
OBSERVATIONS ON THE PROPHYLACTIC USE OF PENICILLIN IN THE WOUNDS OF AERIAL WARFARE <i>Col. Elliott C. Cutler, Lt.-Col. Paul C. Morton, and Major William R. Sandusky</i>	207
PENICILLIN THERAPY IN GONORRHOEA - - - - <i>Major John N. Robinson</i>	211
PENICILLIN THERAPY FOR SYPHILIS - - <i>Major C. R. Wise and Lt.-Col. D. M. Pillsbury</i>	214
BIBLIOGRAPHY - - - - -	217

## NUMBER 126

THE EARLY HISTORY OF SYPHILIS - - - - <i>J. Johnston Abraham, C.B.E., D.S.O.</i>	225
SOME EXPERIENCE OF REPARATIVE SURGERY IN THE MIDDLE EAST - <i>Michael C. Oldfield, M.B.E.</i>	237
SECOND THOUGHTS ON THE ABDOMINAL SURGERY OF 'TOTAL' WAR—A REVIEW OF OVER 1300 CASES <i>Gordon Gordon-Taylor</i>	247
ISCHÆMIC NERVE LESIONS OCCURRING IN VOLKMANN'S CONTRACTURE <i>W. Holmes, the late W. B. Highet, and H. J. Seddon</i>	259
SURGERY IN AN AIRBORNE DIVISION - - - <i>C. J. Longland and Lipmann Kessel</i>	275
THE CLINICAL VALUE OF A GROWTH-PROMOTING SUBSTANCE IN THE TREATMENT OF INDOLENT WOUNDS <i>A. B. Kerr and H. Werner</i>	281
FRACTURES OF THE ZYGOMATIC TRIPOD - - <i>H. Gordon Ungley and Stephen C. Suggit</i>	287
RUPTURE OF THE PANCREAS - - - - <i>Geoffrey Keynes</i>	300
A GASTROSCOPIC CONTROL OF THE TREATMENT OF GASTRIC ULCER BY DUODENAL FEEDING <i>Harry Freeman</i>	303
CAROTID LIGATION FOR INTRACRANIAL ANEURYSM - - - <i>Lambert Rogers</i>	309
FASCIAL SLINGING OF THE SCAPULA AND CLAVICLE FOR DROPPED SHOULDER AND WINGED SCAPULA <i>G. C. Dorling</i>	311
MALIGNANT TRANSFORMATION IN A PREVIOUSLY BENIGN TUBULAR ADENOMA OF THE KIDNEY <i>William Buckley</i>	315
CONGENITAL CYST OF THE COMMON BILE-DUCT CONTAINING STONES AND UNDERGOING CANCEROUS CHANGE - - - - <i>S. T. Irwin and J. E. Morison</i>	319
SHORT NOTES OF RARE OR OBSCURE CASES - - - -	321
IN MEMORIAM: <i>Sir Cuthbert Wallace, Bart., K.C.M.G., C.B.</i>	329
REVIEWS AND NOTICES OF BOOKS - - - -	331

## NUMBER 127

WOUNDS OF THE COLON - - - - <i>C. Naunton Morgan</i>	337
PLASTICITY OF BONE - - - - <i>James F. Brailsford</i>	345
CONGENITAL DEFICIENCY OF THE PERICARDIUM ASSOCIATED WITH A BRONCHOGENIC CYST <i>N. Lloyd Rusby and T. Holmes Sellors</i>	357

	PAGE
ACUTE APPENDICITIS AND THE APPENDIX MASS - <i>A. G. McPherson and J. B. Kinnmonth</i>	365
STENOSIS OF THE SMALL INTESTINE FROM THE CICATRIZATION OF ISOLATED INFLAMMATORY LESIONS <i>Milroy Paul</i>	371
CARCINOMA OF THE ŒSOPHAGUS: RESECTION AND ŒSOPHAGO-GASTROSTOMY <i>Vernon C. Thompson</i>	377
PRELIMINARY REPORT ON THE USE OF WHOLE SKIN-GRAFTS AS A SUBSTITUTE FOR FASCIAL SUTURES IN THE TREATMENT OF HERNIÆ - - - - - <i>George B. Mair</i>	381
COMPLETE RUPTURE OF THE PANCREAS - - - - - <i>J. F. Curr</i>	386
ISCHÆMIC DAMAGE IN THE PERIPHERAL STUMP OF A DIVIDED NERVE <i>H. J. Seddon and W. Holmes</i>	389
A CASE OF TRAUMATIC DIAPHRAGMATIC HERNIA - - - - - <i>Hugh Reid</i>	391
AN OPERATION FOR REMOVAL OF CARCINOMA OF THE ŒSOPHAGUS WITH PRESTERNAL ŒSOPHAGO- GASTROSTOMY - - - - - <i>Hermon Taylor</i>	394
BILATERAL RENAL CARCINOMA - - - - - <i>Howard G. Hanley</i>	399
TRAUMATIC ISCHÆMIA OF PERIPHERAL NERVES, WITH SOME OBSERVATIONS ON VOLKMANN'S ISCHÆMIC CONTRACTURE - - - - - <i>Athol R. Parkes</i>	403
RETAINED INTRAVENTRICULAR FOREIGN BODY - - - - - <i>J. M. Small</i>	414
ASEPTIC ANASTOMOSIS IN GASTRECTOMY - - - - - <i>Charles A. Pannett</i>	418
RIGHT RETROPERITONEAL DIAPHRAGMATIC HERNIA - - - - - <i>N. R. Barrett</i>	421
EXPERIMENTAL SURGERY:— The Control of Hospital Infection of Wounds <i>Robert E. O. Williams, Barbara Clayton-Cooper, T. W. Howat, and A. A. Miles</i>	425
IN MEMORIAM: Ernest William Hey Groves - - - - -	432
SHORT NOTES OF RARE OR OBSCURE CASES - - - - -	433
REVIEWS AND NOTICES OF BOOKS - - - - -	437
NUMBER 128	
THE INTERNAL INGUINAL RING - - - - - <i>W. J. Lytle</i>	441
SOME UNUSUAL THORACIC TUMOURS - - - - - <i>N. R. Barrett and W. G. Barnard</i>	447
THE COMPLICATIONS OF ACQUIRED DIVERTICULOSIS OF THE JEJUNUM AND ILEUM <i>R. Milnes Walker</i>	457
CONSERVATION OF THE METACARPUS BY SKIN AND BONE GRAFTING IN THREE PATIENTS <i>P. B. Moroney</i>	464
OSTEOMYELITIS OF THE CLAVICLE - - - - - <i>Tina Gray</i>	466
OBSTRUCTIVE APPENDICITIS - - - - - <i>W. H. Bowen</i>	468
✓PLASMOCYTOMA OF BONE - - - - - <i>William Tennent</i>	471
OPERATIVE REPLACEMENT OF THE MAMMARY PROMINENCE - - - - - <i>Sir Harold Gillies, C.B.E.</i>	477
MALIGNANT TUMOURS OF THE SMALL INTESTINE - - - - - <i>Kenneth Fraser</i>	479
SPONTANEOUS RUPTURE OF A HYDRONEPHROSIS - - - - - <i>Ronald Reid and W. C. Menzies</i>	491
ABNORMALITY OF THE CALCANEUS AS A CAUSE OF PAINFUL HEEL - <i>A. Fowler and J. F. Philip</i>	494
INGUINAL HERNIA - - - - - <i>W. V. Beach</i>	499
ULCER OF THE SECOND PART OF THE DUODENUM - - - - - <i>P. T. Crymble</i>	500
A CASE OF PSEUDARTHROSIS FOLLOWING FRACTURES OF THE LUMBAR TRANSVERSE PROCESSES <i>Geoffrey Hyman</i>	503

	PAGE
ACTINOMYCOSIS FROM PUNCH INJURIES - - - - - <i>H. Jackson Burrows</i>	506
SUTURE OF LACERATION OF INFERIOR VENA CAVA DUE TO BOMB SPLINTER - - - <i>H. A. Kidd</i>	508
VOLVULUS OF THE SMALL INTESTINE DUE TO A MECKEL'S DIVERTICULUM - - - <i>Rodney Smith</i>	510
A CASE OF REGIONAL ENTERITIS IN CHILDHOOD - - - - - <i>Denis Ebrill</i>	512
DELAYED PARAPLEGIA FOLLOWING FRACTURES OF THE VERTEBRÆ - - - <i>Lambert Rogers</i>	514
FURTHER OBSERVATIONS OF THE CLINICAL VALUE OF A GROWTH-PROMOTING SUBSTANCE IN WOUND TREATMENT - - - - - <i>H. Werner</i>	518
FRACTURE-DISLOCATION OF THE OCCIPITAL BONE - - - - - <i>Selwyn Taylor</i>	522
A URETERIC CALCULUS OF UNUSUAL SIZE - - - <i>George Marangos and G. E. Porter</i>	524
VISITS TO WAR CLINICS :—	
The Canadian Neurosurgical Centre, Hackwood Park, Basingstoke - - - - -	525
SHORT NOTES OF RARE OR OBSCURE CASES - - - - -	531
REVIEWS AND NOTICES OF BOOKS - - - - -	542
GENERAL INDEX TO VOLUME XXXII - - - - -	545

# THE BRITISH JOURNAL OF SURGERY

VOL. XXXII

JULY, 1944

No. 125

## THE EFFECT OF LIGATION ON INFECTION OF THE PATENT DUCTUS ARTERIOSUS\*

By OSWALD S. TUBBS

SURGEON TO AN E.M.S. THORACIC UNIT,  
LATE CHIEF ASSISTANT TO A SURGICAL UNIT, ST BARTHOLOMEW'S HOSPITAL

Six years ago Gross (Gross and Hubbard, 1939), of Boston, Mass., performed the first successful ligation of a persistently patent ductus arteriosus, and sixteen months later the first ligation of a case complicated by subacute bacterial infection was performed in this country with a successful result (Bourne, Keele, and Tubbs, 1941).

In this communication 9 infected cases treated by ligation are reported, 6 of these patients being well to-day and apparently cured. As so little has been published on this subject in the English literature, the essential anatomy and physiology of the ductus arteriosus and the pathological effects of its persistence, with particular reference to the complication of subacute bacterial infection, are described first.

### ANATOMY AND PHYSIOLOGY OF THE DUCTUS ARTERIOSUS

The ductus arteriosus which connects the pulmonary artery at its point of bifurcation to the aorta just distal to the origin of the left subclavian artery is stated to be derived from the sixth left aortic arch. Its function during foetal life is to convey the major part of the output of the right ventricle directly into the descending aorta, thus by-passing the pulmonary circulation; the blood-flow is therefore from the pulmonary artery to the aorta. In the full-term foetus the ductus is 1.5 cm. long and appears to be the direct continuation of the pulmonary artery; its diameter (0.75 cm.) approximates to that of the descending aorta (Fig. 1). It runs almost parallel to the aorta before opening into it at a very acute angle and is relatively much longer and placed more obliquely to the aorta than the same vessel found in subjects in whom patency has persisted into post-natal life.

The normal time and mechanism of closure of the ductus have been discussed at length from time to time. From autopsy examination of

infants, anatomical obliteration of the lumen was found to occur in most subjects within three months, but many authors believed it became impermeable as soon as pulmonary respiration

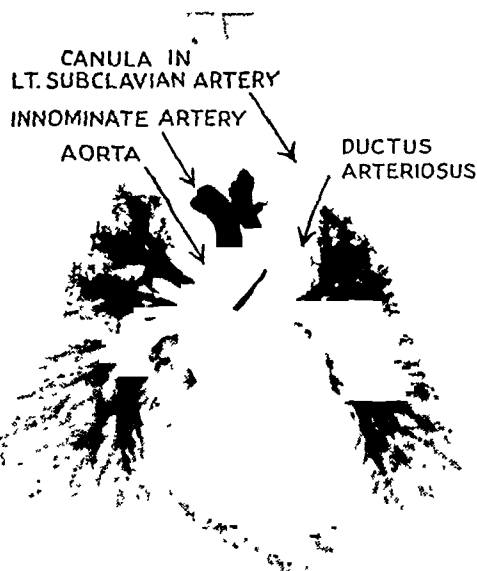


FIG. 1.—Radiograph showing the calibre, length, and position of the ductus arteriosus at birth. Preparation obtained by filling the heart and large vessels of a full-term stillborn foetus with iodide solution through the left subclavian artery. The aorta has been ligated just distal to the entrance of the ductus

was established. In 1939 Barclay, Barcroft, and their co-workers, using sheep foetuses, obtained X-ray cinematographic films of the region of the heart and great vessels after injection of radio-opaque substance into the external jugular vein and produced beautiful graphic demonstration of the functional closure of the ductus shortly after delivery—within five minutes in one experiment. More recently, Kennedy and Clark (1941) have shown from their observations on guinea-pig embryos that this is due to contraction of the muscular wall, the ductus being very rich in

\* The basis of this communication was delivered as a Hunterian Lecture at the Royal College of Surgeons on April 28, 1943.

smooth muscle compared with the elastic tissue structure of the neighbouring vessels. Subsequent anatomical obliteration is essentially the result of sub-endothelial cicatrization and is frequently complete at the end of a month.

### THE EFFECTS OF PATENCY PERSISTING IN POST-NATAL LIFE

In the normal individual, as soon as pulmonary respiration is established, the pressure in the aorta is raised considerably above that in the pulmonary artery, so that, if the ductus remains patent, blood will flow in a rapid stream from the aorta into the pulmonary artery and, as this involves a shunt of arterial blood into a venous stream, there will be no cyanosis. But Maude Abbott (1936) pointed out that cyanosis may appear under conditions causing sufficient rise of pulmonary pressure to produce a temporary reversal of flow, e.g., prolonged crying, violent physical exertion, or in terminal heart failure; and, further, that if the ductus is acting as a compensatory mechanism to one or more other congenital cardiac abnormalities, cyanosis will be present under *resting* conditions.

Where ductal patency is the only abnormality (and this alone is the condition in which we are concerned here), the pulmonary artery becomes dilated and may later become the site of atherosclerosis as a result of the pressure being raised above that of the normal individual, and the right ventricle hypertrophies in response to the increased work of pumping blood against this raised pressure. The left ventricle also hypertrophies as its output has to be increased to compensate for diversion of part of the stream into the pulmonary circulation. Even so, the peripheral circulation may be so diminished as to result in retarded development and nutrition. According to Eppinger and Burwell (1940), from 45 per cent to 75 per cent of the blood put out by the left ventricle passes through the ductus into the pulmonary artery.

It has been suggested that the blood-volume is increased analogous to that which Holman (1937) has shown to occur with arteriovenous aneurysms of the systemic circulation. If this were true, one would expect a greater degree of hypertrophy and dilatation of the heart than is usually seen. One would also expect an immediate slowing of pulse-rate on ligation and a post-operative diuresis with hæmoconcentration. In the 9 cases to be described, slowing of the pulse-rate at the time of ligation has been exceptional, and no post-operative diuresis has been observed. (In an uninfected case, not included in this series, operated on because of early heart failure, immediate slowing of the pulse-rate and post-operative diuresis did occur, but the increased blood-volume may well be explained on the grounds of heart failure *per se*.)

As referred to previously, the persistently patent ductus differs from that found at birth,

being relatively shorter (usually less than 1.5 cm.), of variable diameter (average 1 cm.), but generally wider at its aortic and pulmonary attachments than in the middle, and opening into the *under* surface of the aortic arch. It may have no length at all, rather like a gastro-enterostomy stoma—the so-called 'window type'. Although usually outside the pericardial reflection, in 2 of the 9 cases to be described the medial and anterior surfaces were covered by serous pericardium.

The frequency of complicating subacute bacterial infection is unknown; 29 per cent of the 73 cases over the age of 2 described by Maude Abbott (1936) were infected, but such autopsy statistics give an exaggerated idea of its frequency. It is almost unknown before the age of 6 and uncommon before puberty, the maximum incidence lying between 16 and 25 (Hubbard, Emerson, and Green, 1939). The vegetations occur primarily in the pulmonary end of the ductus, subsequently spreading into the pulmonary artery: sometimes they are found at a very early stage on the anterior wall of the pulmonary artery, a region which is probably under constant strain from the impact of the blood flowing through the ductus. Later, the vegetations may extend back to the pulmonary valve and also involve the aortic end of the ductus or affect other valves. As the vegetations occur primarily in the pulmonary end of the ductus, it is a natural sequence that embolic phenomena in the lungs should precede those in the systemic circulation. The inflammatory process is not confined to the intima of the affected region, but may extend right through the wall into the perivascular tissue and, as a result, the ductus itself may become the site of aneurysmal dilatation (Schlaepfer, 1926). Consequently, surgical isolation of the infected ductus from the surrounding tissues must be expected to be more difficult and hazardous than in the uninfected case.

In the past the prognosis after the supervention of infection has been fatal with exceedingly few exceptions, the duration of life after the onset of infection varying from one month to two years. There are only 2 cases on record (Chester, 1937; Touroff and Tuckman, 1942) in which recovery has taken place without operation, and infection recurred in 1 of these twelve years later.

### DETAILS OF 9 INFECTED CASES TREATED BY LIGATION, WITH DESCRIPTION OF SURGICAL TECHNIQUE EMPLOYED

In October, 1939, a man of 23 was admitted to St. Bartholomew's Hospital with a patent ductus complicated by subacute bacterial endarteritis. Dr. Keele, the physician in charge, asked me to consider ligating the ductus with the idea that it might be possible to close the vessel at its aortic end and again at the pulmonary end and that this might exclude the vegetations from contact with the circulating blood. He also suggested that it might be possible to divide the

ductus between the ligatures and remove the vegetations. Strieder (Grabiell, Strieder, and Boyer, 1938) attempted such an operation in March, 1937, on a similar patient and with the same idea, but he found the ductus so adherent that he was unable to pass a ligature behind it. He tried to obliterate the lumen with a series of plicating sutures, but was not completely successful in accomplishing this. This patient died on the fourth day after operation from acute dilatation of the stomach, and at autopsy vegetations were found to extend back to within 1 cm. of the pulmonary valve; on this account Strieder and his co-workers concluded that the operation had no chance of being successful in this case. Incidentally the ductus turned out to be of the 'window type', which, from the technical viewpoint, was exceedingly bad luck. Later Gross (1939) demonstrated the feasibility of the operation in the absence of infection by his report of 4 consecutive successful results.

On these facts and theories we had to decide whether operation was justified in the presence of infection. In view of the almost hopeless prognosis, and after explaining the experimental nature of the operation to the relatives, we decided to attempt ligation and this patient has turned out to be the first successful case yet reported.

As certain points referable to surgical technique arise in the case reports, the steps of the operation need description first.

### SURGICAL TECHNIQUE OF LIGATION

The technique employed has been very similar to that originated and described in detail by Gross (1939, 1940) for uninfected cases.

All the patients received intravenous glucose-saline and sometimes blood during the operation. If the suggestion (previously mentioned) that these patients have an increased blood-volume were true, intravenous fluid would be contraindicated, although it might be wise to give it at a rate just sufficient to prevent thrombosis so that blood-loss could be immediately replaced in case of severe accidental hæmorrhage. But I am not convinced that the blood-volume is increased. One patient, who appeared clinically in need of transfusion at the end of the operation, but in whom blood-loss had not been severe, improved rapidly as soon as blood was given.

With the exception of Case 1, all the patients have been anæsthetized with a mixture of cyclopropane and oxygen given through an ordinary face-piece by Mr. Rait Smith, for whose help I am extremely grateful. Such anæsthesia produces very quiet shallow respiration and therefore minimal movement of the operative field and yet obviates even the slightest degree of anoxæmia.

With the patient lying on his back with the left arm held in abduction, the skin incision is made over the second left intercostal space and extends from the midline in front to the anterior

axillary line (Fig. 2). A short vertical limb placed centrally over the sternum facilitates retraction later. Pectoralis major is split in the line of its fibres and that part exposed separated from its sternocostal origin. Pectoralis minor is

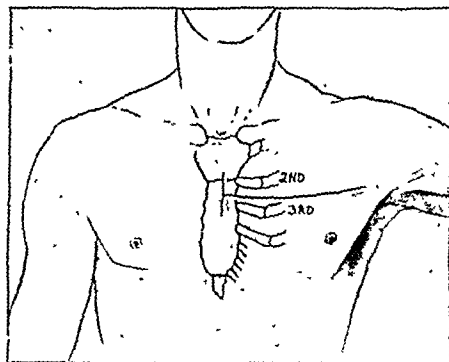


FIG. 2.—The skin incision.

divided obliquely across its fibres. The medial  $\frac{3}{4}$  in. of the second and third costal cartilages are excised together with their perichondrium (Fig. 3). The pleural cavity is then opened through the second intercostal space, the incision stopping short of the internal mammary vessels. By raising the medial ends of the divided ribs, exposure for double ligation of these vessels is obtained, the ligatures serving to control hæmorrhage from small branches: division of the main vessels between the ligatures does not increase the exposure and has therefore been abandoned. After protection of the wound edges with moist gauze pads, the space is opened up with a single rib-spreader (Fig. 4).

This gives full exposure of the region below the aortic arch and the enlarged over-expandible pulmonary artery with a very marked thrill is readily recognized. The mediastinal pleura immediately behind the phrenic nerve and below the aortic arch is picked up with a long clamp and incised vertically. With the exception of one case in which the ductus was almost entirely within the pericardial sac, no difficulty has been experienced in identifying the ductus.

The cellular tissue under the arch of the aorta is gently swept from the anterior surface of the ductus with a pledget of gauze held in a long hæmostatic clamp; this separation is continued by blunt dissection until only the posteromedial surface remains to be freed. The fibro-fatty material surrounding the ductus contains numerous small blood-vessels and one or more hyperæmic lymphatic glands, but a plane of cleavage has usually been found without great difficulty or troublesome bleeding (Fig. 5). The next step—that of freeing the posteromedial surface of the ductus—is the most difficult and worrying part of the operation, for it cannot be done under direct vision. The left index finger is inserted into the cleft between the aortic arch and the



bifurcation of the pulmonary artery and in front of the ductus, and a malleable blunt-ended aneurysm needle is passed through the tissues

appeared to average 1 cm. It is therefore a short wide channel. No. 5 tubular silk has been used as ligature material, two strands being passed

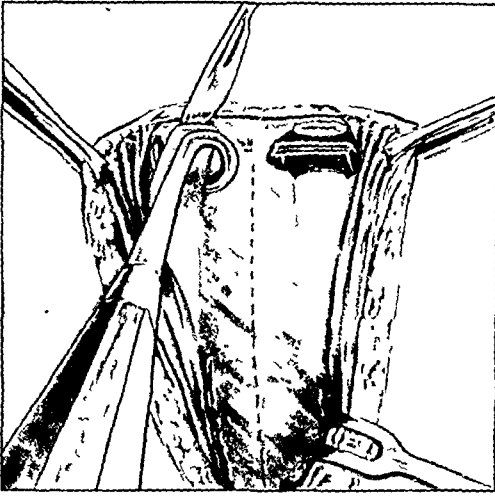


FIG. 3.—The second intercostal space exposed (viewed from the left side of the patient as by the surgeon).

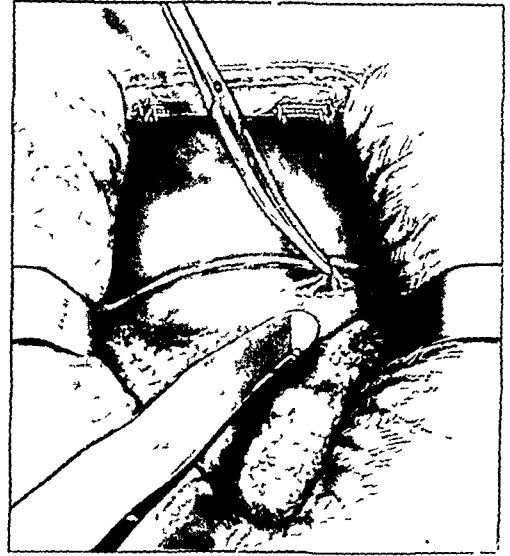


FIG. 4.—Pleural cavity opened and lung depressed under a lighted retractor. The mediastinal pleura has been picked up below the aortic arch and behind the phrenic nerve.

behind the ductus so as to impinge on the left index finger, finally bringing the eye of the needle into view to receive the ligature material. Because of the frequent extension of inflammatory changes through all the coats of the ductus and of the possibility of actual aneurysmal dilatation, it must be obvious that this manœuvre is more

through the eye of the aneurysm needle and each brought through double. The ductus is ligated as near to its pulmonary end and aortic end as

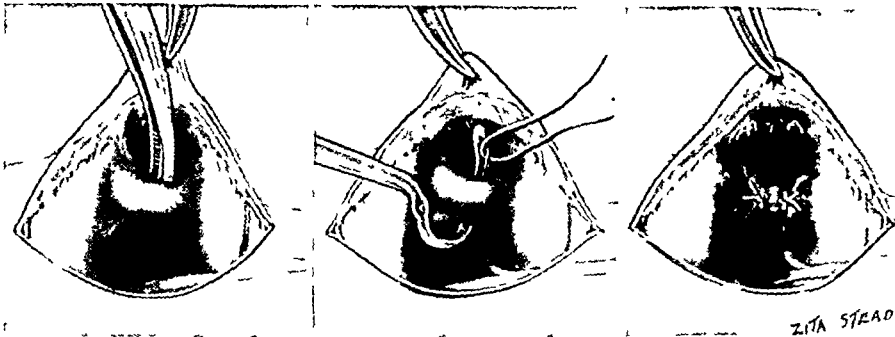


FIG. 5.—Stages in isolation and ligation of the ductus. The proximity of the recurrent laryngeal nerve after leaving the vagus is shown.

likely to cause accidental hæmorrhage than any other during the operation and must therefore be carried out with the greatest care and gentleness. The left recurrent laryngeal nerve, which is readily seen, undoubtedly receives some pressure and possibly stretching; as a result, 2 of this series of 9 cases suffered from temporary post-operative hoarseness. As the infection involves predominantly the pulmonary end of the ductus, it is wise to isolate the aortic end first. In no case has the ductus been more than 1.5 cm. long, the average being about 1 cm. Estimation of the diameter is difficult, but this also has

possible, each ligature being formed of two strands of silk. In some cases the first ligature has greatly reduced but not abolished the thrill in the pulmonary artery, but the second has always completed its destruction. The ligatures have never been placed more than 0.75 cm. apart and often less than this, so that division of the vessel between them would almost certainly have precipitated fatal hæmorrhage. The mediastinal pleura is left unsutured as it is considered preferable for any exudate to escape into the pleural cavity. The chest is finally closed in layers. If the patient is in good condition the lung is

inflated by the anæsthetist using gentle positive pressure before the wound is rendered air-tight, but aspiration with a pneumothorax apparatus after the operation has been completed is likely to put less strain on the circulation.

### CASE REPORTS

(The first 2 cases have been previously reported—Bourne, Keele, and Tubbs, 1941.)

**Case 1.**—A man of 23—the case already referred to—was admitted to hospital in October, 1939, complaining of fever, weakness, and loss of weight. He knew that he had an abnormality of the heart dating from birth, but he had been perfectly well and capable of all activities until five months previously when he had so-called "flu". He had run an intermittent fever ever since and lost 2 st. in weight.

**ON EXAMINATION.**—He appeared thin and very pale, but without cyanosis. Numerous petechiæ were present on the neck, shoulders, and legs. There was slight cardiac enlargement and he had the classic signs of a patent ductus, a thrill extending through systole into diastole being palpable at the pulmonary base and a loud 'machinery' murmur occupying the whole of systole and a large part of diastole, being audible all over the precordium but with its maximum intensity at the pulmonary base. The blood-pressure varied between 110/60 and 150/80, the diastolic pressure being higher than that characteristically found with a patent ductus. The spleen was palpable. Renal embolism was evident by the discovery of much albumin, red cells, leucocytes, and casts in the urine, and renal insufficiency indicated by a blood-urea of 71 mg. per cent. Blood-culture revealed an atypical *Hæmophilus influenzae*. A teleradiogram showed slight enlargement of the heart and prominence in the region of the pulmonary artery.

For two weeks following admission he ran a high intermittent fever uninfluenced by general medical treatment or blood transfusion. Sulphapyridine was then given, starting with 3 g. daily for three days and continued until the time of operation eighteen days later with 1.5 g. daily: this produced dramatic subsidence in fever and improvement in the general condition, but blood-culture remained positive for the same *hæmophilus*.

On Dec. 5 the ductus was ligated, the blood-pressure rising from 108/60 to 120/80 at the moment of ligation. The thrill was abolished by the operation and the added sounds changed to a short rough systolic murmur at the pulmonary base.

The post-operative course was seriously complicated by a severe degree of renal failure, but he survived this and remained afebrile with a sterile blood-culture for three and a half months without any sulphonamide therapy. At the end of this period, blood-culture again became positive and more sulphapyridine was given. Six months after operation, he was up and about, and stated that he had never felt better in his life, but the same organism was again found in his blood. Two months later, however, his blood was sterile and has remained so ever since. After nine months in hospital he was discharged and returned to work. At the present time he remains well, except for occasional headaches which he ascribes to migraine.

This case was a great encouragement, but his recovery was not proven to be the result of ligation of the ductus, particularly in view of bacteria being found in the blood so long afterwards.

**Case 2.**—A girl of 19 was admitted to hospital on Oct. 2, 1940. She had always known that there was something "wrong with her heart", but had been in good health until four months before admission, when she started to complain of headache, lassitude, sweating at night and fever. Ten days before coming into hospital she had left-sided pleuritic pain.

**ON EXAMINATION.**—She did not look ill, but the temperature rose to 100–101° F. each evening. The apex beat was 1 in. outside the mid-clavicular line: the typical systolic murmur and thrill of a patent ductus were present, both persisting well into diastole and most marked in the second left interspace near the sternum. The blood-pressure was 132/40. The spleen was not palpable. The urine was normal. Blood-culture yielded a growth of *Str. viridans* in all tubes on three separate occasions, colony-count in shake culture numbering at first about 300 per c.c. A teleradiogram showed slight enlargement of the heart and prominence of the pulmonary artery: ill-defined shadows in both lung fields, but particularly the right, were also seen, and the possibility of tuberculous infection mooted, but it was thought that they more probably represented areas of infarction, a fact which was confirmed at operation.

After one week in hospital, sulphapyridine was started and resulted directly in disappearance of fever and later in sterility of the blood. After twelve days without fever the ductus was ligated. This caused an immediate rise of blood-pressure from 132/40 to 154/122, but this later settled to 134/74: however, the murmur, including that part extending into diastole, persisted, although less loud than before operation. Gross (1940) has observed this occasionally in his uninfected cases and supposes that it indicates incomplete obliteration of the channel, but Touroff (1940) reported it in one of his infected cases in which accidental hæmorrhage at the time of operation necessitated division of the vessel between ligatures.

A persistent diastolic murmur is difficult to explain if the lumen of the ductus has been completely obliterated, and yet the maintained rise of diastolic pressure and the decrease in the size of the heart and in the prominence of the pulmonary artery seen in radiographs taken later of this patient certainly suggest that obliteration was obtained. However, the convalescence was smooth and the patient put on 1 st. in weight during the first post-operative month. Sulphapyridine therapy was continued for six weeks and the blood kept sterile. When seen recently she was in excellent health and the diastolic fraction of the murmur was only just audible.

**Case 3.**—A girl of 17 was transferred for operation on Oct. 22, 1941. She was known from childhood to have a so-called "weak heart", but she had been perfectly well until ten weeks before admission, when she had some teeth extracted and subsequently felt "run down" and feverish; later she developed left-sided pleuritic pain.

**ON EXAMINATION.**—She looked pale and ill: the temperature rose to 101° F. each evening and the pulse-rate was consistently in the region of 120. The classic signs of a patent ductus were found and the blood-pressure measured 116/58. There was no objective evidence of embolism, but shake cultures of the blood grew 143 colonies of a *Str. viridans* per c.c. Sulphapyridine administration caused temporary subsidence of fever and sterility of the blood, but after a week fever and bacteraemia returned and persisted in spite of various sulphonamides.

On Dec. 4, 1941, the ductus was ligated in spite of the patient being very ill at this time. At operation

infarcts could be seen in the left lung. The ductus was difficult to isolate owing to adhesions and was torn on its anterior wall while clearing the posterior surface,

Six days after admission the ductus was ligated. Great difficulty was experienced in finding a plane of cleavage behind the vessel and an aneurysm needle finally had to be forced through the tissues to get the ligatures round. The operation caused little disturbance and the fever immediately subsided, but blood taken four days after operation yielded 7 colonies of a *Str. viridans* per c.c. For four weeks the temperature remained normal except for two short bouts of pyrexia associated with pain in the chest, presumably caused by pulmonary embolism. But then the diastolic fraction of the murmur, which had disappeared following ligation, reappeared with increasing intensity, although it never became as loud as before. At the same time the temperature returned to its previous high levels and the child died eight weeks after operation.

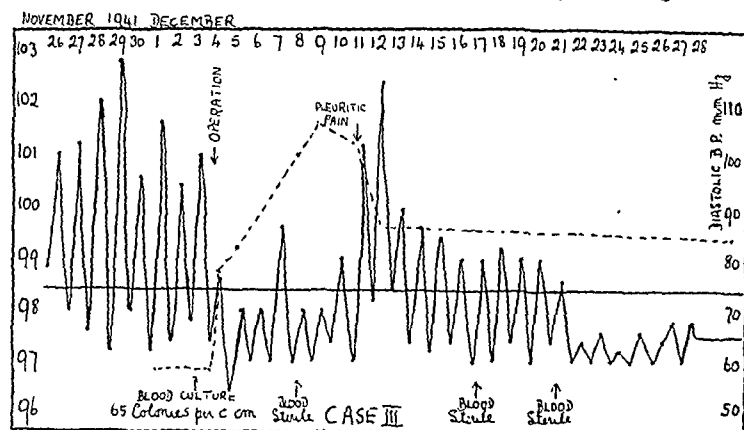


FIG. 6.—Case 3. Temperature chart showing the effect of operation. The results of blood-culture are shown below and the dotted line represents the diastolic blood-pressure.

but the bleeding was easily controlled with a clamp. A dark discoloration and induration of the wall of the left branch of the pulmonary artery were accepted as evidence of vegetations in this position. Seven hours after operation the blood-pressure was 100/76, but later became stabilized at 110/84. As in all the later successful cases the thrill and 'machinery' murmur were abolished, a faint systolic murmur remaining at the pulmonary base. The patient immediately became afebrile and blood taken on the second post-operative day and subsequently was sterile. Apart from sudden pleuritic pain on the left side on the seventh day with rise of temperature to 102° F., presumably due to a pulmonary embolus, the patient had a smooth convalescence (Fig. 6).

This girl reports that she remains perfectly well (May, 1944). This case is a good example of the success of ligation after failure of the sulphonamides even to control the fever.

**Case 4.**—A girl of 10 was received for operation on Dec. 12, 1941. The presence of a patent ductus had been diagnosed at the age of 4, but she had been perfectly well until the present illness started four and a half months previously with vomiting and fever rising to 103°–104° F. each day. She had been treated with intravenous heparin together with sulphapyridine, and, later, by combined venesection and transfusion. The sulphonamide treatment caused the fever to subside for a few days, but the blood did not become sterile and the pyrexia was subsequently uninfluenced by sulphapyridine. When transferred for operation, she looked exceedingly ill, pale, and emaciated. The temperature swung daily between 98° and 104° F. and the pulse varied from 100 to 150. There was extreme arterial pulsation in the neck and a systolic thrill could be felt in the suprasternal notch. The classic signs of a patent ductus were present and the blood-pressure measured 106/56. The spleen was considerably enlarged and the urine contained red cells, white cells, and casts. Blood-culture yielded 130 colonies of a *Str. viridans* per c.c. A radiograph suggested cardiac enlargement, and 'fluffy' shadows could be seen scattered throughout both lung fields, but the child was too ill to sit up for a satisfactory picture.

At autopsy multiple infarcts were found in the lungs. The aortic opening of the ductus was widely patent and led into an aneurysm of this vessel about the size of a golf-ball: the ligatures, still tied, were found in the anterior wall of this aneurysm (Fig. 7). The pulmonary opening of the ductus was blocked by a huge sausage-shaped

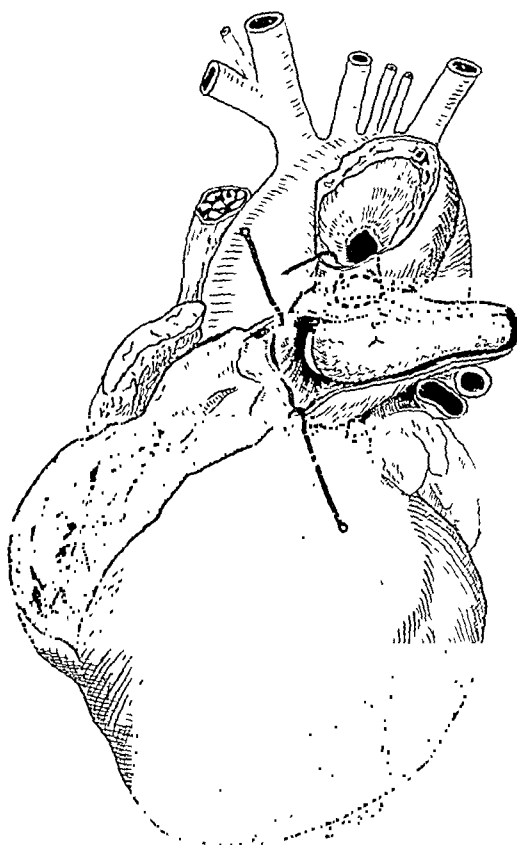


FIG. 7.—Case 4. Drawing of heart and main vessels as seen at autopsy (see text).

thrombus which lay horizontally in the two branches of the pulmonary artery almost occluding them and containing innumerable Gram-positive cocci. The kidneys showed embolic nephritis and the spleen was enlarged.

I believe the most likely explanation of the clinical and pathological findings is that the posterior wall of the ductus was damaged at operation by the passage of the ligatures, which subsequently cut through, thereby re-establishing the lumen of the ductus. The ligatures were thus left encircling the anterior wall only and this became progressively aneurysmal.

**Case 5.**—A woman of 29 was admitted on Jan. 12, 1942, complaining of recurrent fever, shortness of breath, and pain in the right shoulder. Congenital heart disease had been discovered at the age of 3, but she had been symptomless until eighteen months previously when she had unexplained fever lasting a month. At this time clinical and radiological signs of a right basal pleurisy were found, but two blood-cultures were sterile. She remained well for nearly a year after this, but then had another febrile attack and remained in bed at home for four weeks. Two months later the fever and right-sided pleurisy recurred and she became short of breath.

**ON EXAMINATION.**—She did not look seriously ill, but the temperature rose to  $100^{\circ}$  or  $101^{\circ}$  F. each evening, and the pulse-rate averaged 110. The classic signs of a patent ductus were present and the blood-pressure measured 102/58. The signs of either a high right diaphragm or basal pleural effusion were found and the tip of the spleen was palpable. The urine was normal. Blood-culture yielded 86 colonies of a *Str. viridans* per c.c. X-ray films of the chest showed a high right diaphragm, no cardiac enlargement, and little, if any, enlargement of the pulmonary artery.

The ductus was ligated on Feb. 2, which caused the diastolic blood-pressure to rise from 58 to 88. An enlarged gland adjacent to the ductus was excised

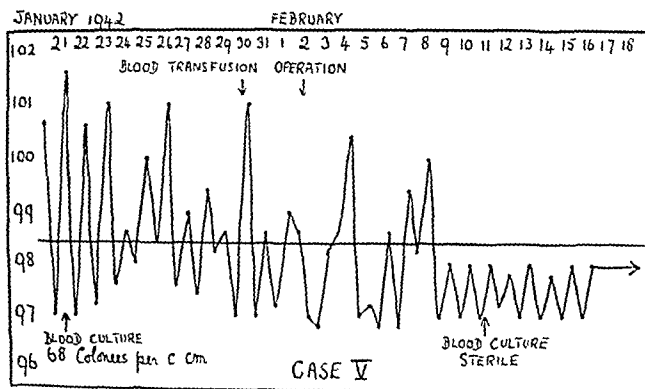


FIG. 8.—Case 5. Temperature chart showing the effect of operation. No sulphonamide was given.

and a bacteriological culture made from it, but this was sterile. The operation abolished the diastolic fraction of the murmur, but a systolic murmur remained. The immediate post-operative period was marred by collapse of the left lower lobe, but this cleared up rapidly. Nine days after operation the blood was sterile. She has remained in good health ever since and, when seen in April, 1943, volunteered

that she could exert herself with less breathlessness than ever before.

This case was treated surgically without any pre- or post-operative sulphonamide therapy, so that the effect of the operation alone might be more accurately assessed (Fig. 8).

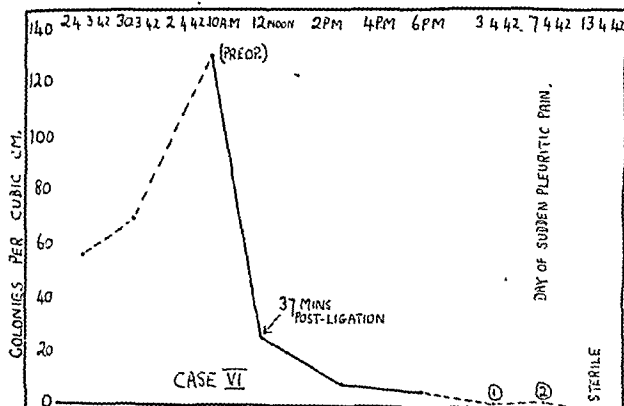


FIG. 9.—Case 6. Graph showing the immediate effect of ligation on colony counts obtained from blood-cultures.

**Case 6.**—A woman of 22 came into hospital on March 23, 1942, complaining of left-sided pleuritic pain. She had no previous knowledge of heart disease and had always been capable of normal activities. Five months before admission she had some teeth extracted and felt weak for several days afterwards, but returned to work. A month later she again felt weak and attended her doctor, who told her she had valvular disease of the heart and anaemia. After another month she developed right-sided pleurisy and became short of breath. The pleuritic pain recurred four weeks and again six weeks later: on the second occasion (two weeks before admission) she had fever up to  $103^{\circ}$  F., felt tired, and suffered from palpitations. There had been amenorrhoea for four months.

**ON EXAMINATION.**—She looked sallow and the temperature rose to  $102^{\circ}$  or  $103^{\circ}$  F. each evening. The classic signs of a patent ductus were present and the blood-pressure measured 125/50. The percussion note was impaired and the air entry diminished at the right base. The spleen was not palpable. The urine contained blood, but there was no other evidence of systemic embolism. Blood-culture yielded 56 colonies of a *Str. viridans* per c.c. A telerradiogram showed fullness of the upper part of the left border of the heart and an ill-defined loss of translucency in the right lower lung field. Sulphanilamide lowered the fever for four days, but subsequently had no effect and was therefore omitted.

The ductus was ligated on April 2; this caused a rise of diastolic blood-pressure to 80 and did away with the thrill and diastolic murmur. The most interesting observation

made from this operation was the amazing rapidity with which the bacteria were removed from the blood-stream as a result of ligation, for blood taken immediately before operation grew 130 colonies of a *Str. viridans* per c.c., whereas that taken thirty-seven minutes after ligation yielded 26 colonies, that four hours after 8 colonies, that seven hours after 5 colonies, and that taken next morning only 1 colony per c.c. (Fig. 9).

The convalescence was uneventful except for a lesion of the upper trunk of the left brachial plexus which dated from the time of operation and took three months to clear up completely; this complication was undoubtedly caused by stretching of the plexus as a result of inadequate support of the abducted arm. The patient also had sudden pleuritic pain on the fifth post-operative day with a rise of temperature to 102° F., and blood taken on this day grew 2 colonies of *Str. viridans* per c.c. The patient became afebrile on the ninth day and blood-culture was sterile on the eleventh day. She has kept in good health ever since.

**Case 7.**—A man of 26 was transferred for operation on April 13, 1942. He had known for many years that he had a congenital abnormality of the heart, but, apart from osteomyelitis of the jaw five years previously, had been perfectly well until Christmas, 1941, when he had "gastric flu" associated with fever which persisted. At the end of January, 1942, he had sudden severe pain in the left thigh and was admitted to hospital fourteen days later. A diagnosis of subacute bacterial endarteritis superimposed on a patent ductus was made and he was treated by repeated blood transfusion, antitoxin serum, and sulphapyridine, but, in spite of all therapy, continued to run an evening pyrexia between 100° and 104° F. After receiving a blood transfusion of 2½ pints on March 28, 1942, he had severe precordial pain, and the heart, already enlarged, became greatly dilated.

**ON EXAMINATION.**—He looked pale and ill; there was no cyanosis, but he was orthopneic and very short of breath. There was marked pulsation with a systolic thrill at the suprasternal notch, and this thrill could also be felt, although less well, in the second left intercostal space. The apex beat was situated 6 in. from the midline and a rough systolic and diastolic murmur could be heard all over the precordium, with its maximum intensity in the pulmonary area. The blood-pressure was 146/40. Scattered rhonchi and râles were heard over both lungs with large numbers of fine râles at both bases. The liver and spleen were enlarged, but there was no peripheral œdema. The urine contained numerous red cells. Blood-culture yielded 127 colonies of a *Str. viridans* per c.c. It was clear that we were faced with a new problem, for this patient had advanced left-sided heart failure in addition to subacute bacterial endarteritis and the risk of ligation would obviously be greater than in the previous cases. However, it seemed equally clear that he should be given the chance which operation might offer and the ductus was therefore ligated on April 23. It was found in a very medial position, covered by serous pericardium on its anterior and medial surfaces: the pericardium was opened but an aneurysm needle could not be passed round the postero-medial surface of the ductus and the ligature was ultimately passed on a curved round-bodied needle. During all this manipulation the patient's condition remained satisfactory. The systolic blood-pressure rose to 222 during the first thirty minutes of the operation and remained in the region of 200 until the ligature was tied. At this moment the diastolic pressure rose from 60 to 80, but that in systole fell rapidly and the pulse became feeble and irregular.

When the operation had been completed, the patient was pale and cyanosed, and the pulse rapid and feeble. Morphine was injected to control his restlessness and oxygen administered, but the patient died 45 minutes after completing the operation. At autopsy the right ventricle was dilated but did not appear hypertrophied, whereas the left ventricle

showed considerable hypertrophy. A pedunculated partially-organized vegetation containing Gram-positive cocci was found on one aortic cusp. Vegetations were also present in the bifurcation and left branch of the pulmonary artery. There was induration at the site of the ductus due to fibroblastic granulation tissue, but no organisms were demonstrated in this material. The ligature, which had closed any visible lumen in the ductus, was found to have been passed through the medial part of the lumen of the vessel, but no blood leak had resulted. There were several old infarcts in the lungs and the kidneys showed embolic nephritis. The liver and spleen were both grossly enlarged and congested, the liver showing typical 'nutmeg' change. If this man had not succumbed to acute heart failure as a result of the ligation, I think it is certain that he would not have recovered from the infection owing to the vegetation on an aortic cusp.

**Case 8.**—A man of 33 was admitted on March 1, 1943, complaining of weakness, fever, and loss of weight. He had known from the age of 14 that he had a congenital abnormality of the heart and had therefore avoided the more strenuous forms of exercise; however, he had been able to cycle, dig, etc., with only slightly more breathlessness than that experienced by the normal individual. Early in December, 1942, circumcision had been performed and the wound took a month to heal. A month after the operation, he started severe night sweats and became extremely fatigued. After six weeks he was admitted to hospital where he was found to have the classic signs of a patent ductus, high fever, and a palpable spleen. Blood-culture had yielded a growth of a *Str. viridans* and *Staph. aureus*. He developed right-sided pleuritic pain following admission. Sulphathiazole was given and his fever subsided: the drug was continued until the time of transfer for operation, by which time he had lost 3 st. in weight.

**ON EXAMINATION.**—He appeared pale and ill; the pulse was of Corrigan type, the blood-pressure measuring 146/54. Blood-culture was sterile. A telerradiogram showed no enlargement of the heart, but prominence of the pulmonary artery. Sulphathiazole was discontinued and for three days the temperature only reached 99.8° F. in the evening. High fever then recurred and blood-culture yielded an unidentifiable Gram-negative bacillus. Sulphathiazole was restarted, but, after causing an initial reduction in fever, failed to have any influence.

The ductus was ligated on March 15. The passage of the ligatures necessitated opening the pericardial sac as the anteromedial wall of the ductus was clothed with the membrane. There was an excess of pericardial fluid, and œdematous adhesions were present in the region of the ductus. The pericardium was left unsutured. An electrocardiogram was taken during the operation and a normal tracing obtained fifteen minutes before and after ligation, but that taken one minute after ligation showed numerous extrasystoles. Blood taken immediately before operation grew 25 colonies of a coagulase-negative *Staph. albus* per c.c., whereas that taken thirty minutes after completion grew 6 colonies of the same organism per c.c., and blood taken three hours and again six hours after was sterile. However, the nature of the infecting organisms found in this case has been so variable that it would seem unwise to stress these findings. The thrill and diastolic murmur were entirely abolished by the operation and the diastolic blood-pressure raised to a minimum of 76. Severe precordial pain and loud pericardial friction occurred the day following

surgery and lasted for forty-eight hours—undoubtedly the result of opening the pericardial sac. During the first two weeks he developed left-sided pleuritic pain with signs of consolidation over the left lower lobe, and abdominal pain with diarrhoea and mucus-containing stools, the more acute phases of these complications being accompanied by fever up to  $103^{\circ}$  F. It is

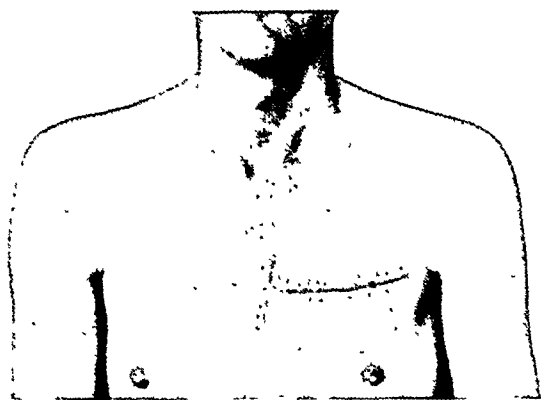


FIG. 10.—Case 8. Photograph of wound six weeks after operation.

probable that the pulmonary lesion was the result of embolism, but doubtful if the abdominal symptoms had the same aetiology. Subsequently he became afebrile and has remained perfectly well ever since (Fig. 10).

**Case 9.**—A girl, aged 15, was transferred for operation on April 22, 1943. She was known from early childhood to have a patent ductus and, as a result, had lead an extremely sheltered life. However, she had been in her normal health until a month before transfer, when she developed a cough with yellow, sometimes blood-streaked, sputum and upper left pleuritic pain. She was admitted to hospital on March 30 and was found to be febrile (temperature  $103^{\circ}$  F.) with a respiratory rate of 35 and to have signs of consolidation in the left upper chest. The white blood-count was 21,400 per c.mm., and a radiograph showed a large opacity in the left upper lobe extending down to the hilum and obscuring the region below the aortic arch. A diagnosis of pneumonia was made and she was treated with sulphamezathine and, later, sulphadiazine without obvious effect on the fever, but the radiological opacity gradually shrank and showed evidence of excavation. On April 14 blood-culture grew a *Str. viridans* and the diagnosis was amended to subacute bacterial infection complicating a patent ductus, but it was not clear whether this was secondary to the pulmonary infection or the pulmonary consolidation secondary to a large embolus.

**ON EXAMINATION.**—She looked pale, sallow, and thin, but no petechiae could be found. The temperature rose each evening to between  $100^{\circ}$  F. and  $103^{\circ}$  F. The classic signs of a patent ductus were present, but no abnormal signs were found at this time in the lungs. The blood-pressure measured 120/55. The spleen was not palpable and the urine was normal. Shake cultures of the blood yielded 54 colonies of a *Str. viridans* per c.c. and examination of the sputum showed the same organism predominating. A teleradiogram showed an elongated opacity underlying the second rib in front and extending from the left hilum to the chest wall: this still obscured the upper part of the left border of the heart and showed cavitation peripherally: a clearly-defined oval opacity at the right hilum was interpreted as an enlarged gland.

The ductus was ligated on May 3. Technically this was by far the most difficult yet tackled as the upper lobe was densely adherent to the chest wall along the second rib, and these adhesions continued on to the mediastinum below the aortic arch, obscuring the anatomy so much that identification of the ductus almost entirely depended on palpation: dissection was also made difficult by oedema, induration, and increased vascularity of the tissues. Nevertheless, the operation was completed without accident and the diastolic bruit entirely disappeared. Initially both systolic and diastolic pressures were low as a result of shock, but a week after operation the diastolic pressure measured 78 (pre-operative, 55). Blood-culture taken immediately before operation grew 97 colonies of *Str. viridans* per c.c., whereas that taken immediately after grew 5 colonies and that taken ten hours after 6 colonies per c.c. Repeated pulmonary embolism with rigors occurred during the two weeks following operation, but the temperature then settled to below  $99^{\circ}$  F. and blood-culture on the sixteenth post-operative day was sterile. Alas! this encouragement was short-lived, for at the end of a month the temperature returned to its previous remittent, or intermittent character, blood-culture grew large numbers of *Str. viridans*, repeated peripheral embolism occurred (no further pulmonary embolism was detected), and a soft diastolic murmur of aortic type developed. The girl finally died nearly four months after operation.

At autopsy, the heart showed slight enlargement affecting the two sides equally. The valves of the right side appeared normal, but both the mitral and aortic cusps were thickly covered with large friable vegetations containing innumerable streptococci; the valves did not show any evidence of congenital malformation or chronic inflammatory change. The aortic and pulmonary ends of the ligated ductus, the lumen of which was completely obliterated, were represented by shallow depressions with a smooth floor and devoid of thrombus. In the left pulmonary artery immediately lateral to the pulmonary attachment of the ductus there was a considerable amount of firm thrombus which covered over the opening of a saccular aneurysm 1.5 cm. in diameter and lying between the distal part of the aortic arch and the left pulmonary artery: this aneurysm was filled with very firm laminated clot. At the site of bifurcation of the right pulmonary artery there was another larger saccular aneurysm which was also filled with laminated clot. Microscopical examination of the thrombi in the two aneurysms and in the left branch of the pulmonary artery showed that they were of similar laminated structure and free from bacteria. There were numerous old infarcts in the lungs and cavitation with surrounding consolidation in the left upper lobe; this cavitation probably resulted from liquefaction of a large infarct as there was much blood-pigment in the surrounding tissue. The spleen, which was enlarged, and both kidneys showed infarction, undoubtedly secondary to the left-sided valvular vegetations.

Co-ordination of the clinical and pathological findings in this case is much complicated by the discovery of the aneurysms of each branch of the pulmonary artery. The aneurysm of the right branch was certainly present before operation as it showed as an oval opacity at the right hilum in a pre-operative X-ray picture (although, at the time, this shadow was falsely interpreted as an enlarged gland). It is probable that the small aneurysm of the left branch also pre-existed operation as retrospective examination of the same X-ray film reveals a shadow compatible with its presence although much obscured

by the opacity extending down from the left upper lobe. It is probable that these aneurysms were unconnected with the subacute bacterial infection of the ductus as aneurysms of the pulmonary artery have been described before in association with a simple patent ductus. The lamination and absence of bacteria in the contained thrombi suggest they were not formed as the direct result of infection.

The clinical response to ligation of the ductus—immediate reduction in bacteraemia and later temporary sterility of the blood, with marked diminution in fever—strongly suggest that the ductus or adjacent part of the pulmonary artery was the main site of bacterial vegetations at the time of operation, and it is most disappointing that the post-mortem examination did not show in what way the vegetations had been destroyed.

It is, of course, obvious that death was due to infection of the mitral and aortic valves, evidence of which was entirely lacking before operation.

results in the cure of subacute bacterial infection complicating a patent ductus.

It is obvious that the original theory on the basis of which the first case was treated surgically does not explain why many of these patients have recovered following ligation, for the ligatures cannot possibly have been placed sufficiently far apart to include all the vegetations between them. In addition, this theory could not account for the remarkable reduction in fever lasting a month which occurred in the child (Case 4) who ultimately succumbed following recanalization of the ductus and in whom an enormous vegetation was found in the pulmonary artery at autopsy, presuming that at least part of this thrombus was present at operation eight weeks before death. Further, in Case 3, dark discoloration of the wall of the left branch of the pulmonary artery, which

Table I.—SUMMARY OF NINE CASES TREATED BY LIGATION

CASE No.	AGE	SEX	APPARENT CAUSE OF INFECTION	DIASTOLIC PRESSURE		INFECTING ORGANISM	POST-OPERATIVE EMBOLISM	RESIDUAL CARDIAC MURMURS	RESULT
				Pre-operative	Post-operative				
1	23	M.	?	60	80	Atypical <i>H. influenzae</i>	None	Short systolic	Well (4 yr. 5 mth.)
2	19	F.	?	40	74	<i>Str. viridans</i>	None	Systolic and diastolic	Well (3 yr. 8 mth.)
3	17	F.	Dental extraction	58	76	<i>Str. viridans</i>	Pulmonary (7th day)	Faint systolic	Well (2 yr. 6 mth.)
4	10	F.	?	56	82	<i>Str. viridans</i>	Pulmonary (repeated)	Faint systolic. Diastolic later	Died (8 wk.)
5	29	F.	?	58	88	<i>Str. viridans</i>	None	Systolic	Well (2 yr. 4 mth.)
6	22	F.	Dental extraction	50	80	<i>Str. viridans</i>	Pulmonary (5th day)	None	Well (2 yr. 2 mth.)
7	26	M.	?	60	86	<i>Str. viridans</i>	—	—	Died (1 hr.)
8	33	M.	Circumcision	54	76	<i>Staphylococcus, Str. viridans, Gram—ve bacillus</i>	Pulmonary (during 1st wk.)	Faint systolic	Well (1 yr. 3 mth.)
9	15	F.	?	55	78	<i>Str. viridans</i>	Pulmonary (1st wk.). Repeated systemic (later)	Faint systolic. Aortic diastolic (later)*	Died (4 mth.)

\* The patient's doctor now (May, 1944) reports that the 'humming-top' murmur has returned.

## RATIONALE OF LIGATION IN THE PRESENCE OF INFECTION

Before discussing this difficult problem, it should be made clear that the recovery rate in this series (66 per cent) is approximately the same as that obtained by other surgeons. In the United States more than 30 infected cases have been treated by ligation and a large proportion of these have got well (Shapiro, 1943). (This includes 12 cases operated on by Touroff (1943), of which 10 survived operation and 7 recovered completely.) In this country Sellors (1943), Price Thomas (1943), and others have been equally successful. We may therefore take it as an established fact that ligation very frequently

felt firm, almost certainly marked the position of vegetations and yet this patient got completely well.

Boldero and Bedford (1924), commenting on the rarity of subacute bacterial endocarditis on the right side of the heart unless there was a leak into it from the left side, suggested that this might be due to venous blood being inimical to the growth of bacteria. If this suggestion were true, a ready explanation for the success of ligation would be available, for, if this were done at a stage when the vegetations were limited to the pulmonary side, the bacteria would be deprived of the arterial stream coming through this channel and might therefore be expected to die. It would further explain the observation (Touroff, 1943)



that those cases showing pre-operative systemic embolism, which is evidence of extension to the aortic opening of the ductus or to the aortic or mitral valves, rarely if ever, recover. (In this connexion, in our present state of knowledge, I would not subscribe to the view that such evidence is a contra-indication to operation. It is also worth noting that embolic nephritis and perhaps even cutaneous petechiae may not necessarily indicate such extension, as *small* emboli can clearly pass through the pulmonary capillary bed, *vide Case 1* which recovered.) However, there is no bacteriological evidence to support this thesis and, even if there were, the extremely rapid removal of bacteria from the blood-stream following ligation, demonstrated in *Cases 6* and *9* and possibly *Case 8*, seems too quick a process to make this explanation likely.

Touroff (1942, a) has described in detail a theory which supposes that the cessation of the rapid stream through the ductus results in much diminished fragmentation of the infected clot, and that the lung capillaries, now less dilated and fed by an arterial stream no longer raised in pressure or volume, are able to filter off the few emboli which are formed. This hypothesis depends on several factors which require consideration:—

1. It assumes that the bacteria already circulating in the blood are very rapidly destroyed or removed from it. This would be expected in view of the experimental demonstration that organisms injected intravenously disappear with extreme rapidity from mammalian blood provided the source of supply is not continued (Reichell, 1939).

2. The theory pictures diminished fragmentation of the thrombus as a result of exposure to a less forceful blood-stream. This is reasonable, but obviously cannot be supported by experimental evidence.

3. It accords to the lungs an ability to act as a bacterial filter. The ability of the pulmonary capillaries to perform such a function receives support from Touroff's (1942, b) discovery of far fewer bacteria in a sample of aortic blood compared with one taken from the pulmonary artery at the time of operation, but before ligation of the ductus.

4. It presumes that the static thrombus heals by a process of organization. This is reasonable pathology, support for which was sought at the autopsy in *Case 9*, but unfortunately there was no clue as to the original site of the vegetations: the floor of the depression found in the pulmonary artery and representing the pulmonary end of the ductus was formed of well-organized fibrous tissue, but there appears no justification for assuming that this resulted from organization of vegetations.

To summarize, we do not yet know why most of these patients have got well, but Touroff's theory seems the most reasonable yet advanced. Cases treated by ligation in the future should be studied most carefully in order to discover the

true explanation, for it is possible that this might have some bearing on treatment of subacute bacterial endocarditis involving other abnormalities.

## SUMMARY

The anatomy, physiology, and pathology of the ductus arteriosus are briefly reviewed.

Nine cases of subacute bacterial endarteritis complicating a patent ductus and treated by ligation are described; 6 of these patients are well to-day, from fifteen months to over four years after operation.

The technique of the operation is described.

The reason why ligation frequently results in cure of the infection is discussed.

## CONCLUSION

The effect of ligation on infection of a patent ductus has been dramatic, although perhaps unexpected, and infection must now be considered an absolute and urgent indication for operation. Under these circumstances it is important that the supervention of infection should be diagnosed early; any patient with a patent ductus who runs an unexplained fever for more than two weeks should be suspected of this complication.

It is difficult to pay proper tribute to all who have helped in this work for it represents a 'combined operation' rather than the effort of a single individual. I would like to thank the physicians who referred the cases for operation: Dr. K. D. Keele, Sir Thomas Lewis, Dr. A. E. Gow, Dr. H. V. Morlock, Dr. Ronald Jones, Dr. E. F. Scowen and, in particular, Dr. Geoffrey Bourne, who has given me invaluable advice with all the cases. Dr. R. H. A. Swain gave much time and took infinite pains with the bacteriological investigations, and Professor L. P. Garrod gave his expert help when military service called Dr. Swain away. It would be ungrateful if I did not also acknowledge the very important part played by first-rate nursing care—especially that of Sister Piper.

## REFERENCES

- ABBOTT, MAUDE E. (1936), *Atlas of Congenital Heart Disease*. New York: American Heart Association.
- BARCLAY, A. E., BARCROFT, J., BARRON, D. H., and FRANKLIN, K. J. (1939), *Brit. J. Radiol.*, **12**, 505.
- BOLDERO, H. E. A., and BEDFORD, D. E. (1924), *Lancet*, **2**, 747.
- BOURNE, G., KEELE, K. D., and TUBBS, O. S. (1941), *Ibid.*, **2**, 444.
- CHESTER, W. (1937), *Amer. Heart J.*, **13**, 492.
- EPPINGER, E. C., and BURWELL, C. S. (1940), *J. Amer. med. Ass.*, **115**, 1262.
- GRABIEL, A., STRIEDER, J. W., and BOYER, N. H. (1938), *Amer. Heart J.*, **15**, 621.
- GROSS, R. E. (1939), *Ann. Surg.*, **110**, 321.
- (1940), *J. Amer. med. Ass.*, **115**, 15.
- and HUBBARD, J. P. (1939), *Ibid.*, **112**, 729.



HOLMAN, E. (1937), *Arteriovenous Aneurysm*. New York: Macmillan Co.  
 HUBBARD, J. P., EMERSON, P. W., and GREEN, H. (1939), *New Eng. J. Med.*, **221**, 481.  
 KENNEDY, J. A., and CLARKE, S. L. (1941), *Anat. Rec.*, **79**, 349.  
 REICHEL, H. A. (1939), *Proc. Mayo Clin.* **14**, 138.  
 SCHLAEPFER, K. (1926), *Arch. intern. Med.*, **37**, 473.  
 SELLORS, T. H. (1943), personal communication.

SHAPIRO, M. J. (1943), *Amer. Heart J.*, **25**, 187 (Discussion of Touroff's paper).  
 THOMAS, C. P. (1943), personal communication.  
 TOUROFF, A. S. W. (1940), *J. thorac. Surg.*, **10**, 59.  
 — (1942, a), *Amer. Heart J.*, **23**, 847.  
 — (1942, b), *Proc. Soc. exper. Biol.*, N.Y., **49**, 568.  
 — (1943), *Amer. Heart J.*, **25**, 187.  
 — and TUCKMAN, L. R. (1942), *Ibid.*, **23**, 857.

## WAR SURGERY IN THE ROYAL AIR FORCE

BY AIR COMMODORE STANFORD CADE

CONSULTANT IN SURGERY, ROYAL AIR FORCE

THIS paper is an attempt to place on record the surgical activities of the Royal Air Force during the four years of war. The objects of surgical services in war as in peace are the same: to save life, to limit morbidity, and to restore function. Yet in the field of surgical endeavour war always leads to great advances made in rapid strides. Each of the three Services has its own special problems. The dominating problem in the Royal Air Force is the care of air-crews. These carefully selected and highly trained young men are fighting either alone, as in the case of fighter pilots, or in small units of a few men forming that unique partnership—an air-crew. These men live and work in exceptional conditions; they are submitted to the special risks of flying at high speeds, to the hazards of weather, altitude, and cold, and, in addition, to the perils of exposure to the dangers from enemy action common to all Services. The air-crews are outnumbered many times by the ground personnel consisting of trained technicians: fitters, riggers, mechanics, engineers, armourers, electricians, instrument repairers, as well as equipment and medical personnel, all exposed directly, although to a lesser degree, to risks attributable to war. Both air-crews and ground staff and every member of the ancillary branches of the Service are liable to incidental surgical diseases and injuries which hamper the war effort. There are, therefore, problems special to the Royal Air Force and others common to all. What are these problems and what is the organization dealing with them? What facilities does the Royal Air Force provide, and what degree of success has been achieved?

### THE SPECIAL PROBLEMS

**Fatal Injuries.**—In certain circumstances loss of life results from the multiplicity of injuries. In no other Service, and in no other conditions is this such a clear-cut and oft-repeated event: mid-air collisions, diving into the ground or sea at tremendous velocity, fierce and rapid conflagrations where petrol, cooling mixture, ammunition, and high explosives transform the aircraft into a vast blazing furnace. These accidents result in injuries which allow of no survival.

Analysis of these cases shows that they fall into three groups: The first results in a pulverization of the whole body; uncontrolled power-diving where the impact is extremely severe results in a disintegration of the body into small particles, the recognizable anatomical parts being no bigger than the head of the femur, or a portion of a finger, a toe, or a vertebra. The second group is more common and results in multiple injuries and fractures. Thus, a very recent mid-air collision of two four-engined aircraft returning at night from a successful operational sortie, resulted in thirteen deaths; examination revealed that, in only two were the fractures compound; in the others, although the skin was intact, showing bruising only, most of the bones were fractured, as many as twenty fractures being detected; the scalp may be intact and yet all the bones of the vertex and of the base are splintered into small fragments. Visceral injuries in such cases are severe and extensive; injuries to the heart, lungs, and main vessels are common; death is instantaneous in all but the very few cases that survive a few hours only. The third group of cases comprises burns so extensive as to result in partial or complete incineration. All these cases are fatal and death is instantaneous. It is at present difficult to visualize any preventive measures likely to diminish the incidence of such disasters.

**Common Non-fatal Injuries.**—Of the large number of war injuries those most commonly met with in flying personnel and of special interest to the Air Force surgeon are selected for more detailed consideration: Burns, wounds, frost-bite, immersion injuries, and head injuries. Fractures are not dealt with in this review except in the section on the General Organization of the Surgical Services.

### BURNS

Burns account for an important number of R.A.F. casualties among air-crews. At the time of the Battle of Britain, most surgeons had but little experience of this type of injury, only a few took a special interest in them, and tannic acid loomed very large in the treatment. The burns

at the time of the Dunkirk evacuation provided experience of the immediate treatment and subsequently showed the sequelæ thereof. It is, however, from the time of the Battle of Britain that great interest was aroused in this subject, resulting in the formation of Special Burn Centres within the R.A.F. medical organization. The complex problems, both of pathology and of treatment, have stimulated interest, and rapid progress has been made in the management of these cases.

Accurate observation of early and late effects of burns has led to variations and improvement in the technique and in the principles underlying the rationale of the treatment. Strict adherence to the narrow path of accepted methods was quickly abandoned in favour of open-minded observation of the effects of different therapeutic measures.

The special problem of the burned R.A.F. crews is in the majority of cases that of second-degree and third-degree burns of the face and hands. Burns of the trunk or of the lower extremities differ not at all from those seen in other services or met with among civilian casualties.

Before discussing methods of treatment, attention must be drawn to certain features of clinical and pathological importance:—

1. In R.A.F. crews the survivors belong to a group where the area of the burn is relatively small, the part affected localized to the hands and face, the degree of burn second or third. Therefore, *mortality* in this type is small, but *morbidity* is great.

2. There is real difficulty in distinguishing soon after the infliction of the injury, second-degree from mild third-degree burns. There is, of course, no difficulty at either end of the scale, but in the borderline between partial and total skin loss even the most experienced cannot with certainty establish an accurate diagnosis. James Dingwall, of the Cornell University, recently described a method of distinguishing second-degree from third-degree burns. It consists in the intravenous injection of 10 c.c. of a 20 per cent solution of fluorescein. Within fifteen seconds from the time of injection the burned area when examined under ultra-violet light is said to appear yellow or yellow-green if only of second degree, and black if of third degree. This test merits further investigation.

3. The immediate response of the tissues to thermal injuries is *œdema*. It is very marked, of rapid onset, and progressive; it affects vitally the choice of the immediate and subsequent treatment. It is the most important clinical manifestation and it has been shown experimentally that burns result in an immediate and marked increase of lymph-flow. Similarly, inhalation of flame results in *œdema* of the glottis, larynx, and trachea.

4. For a considerable time the blister fluid remains sterile—a fact to be remembered, especially

in the first-aid treatment. Nevertheless, as pointed out by Colebrook and others, blister fluid is an excellent culture medium and organisms present in the deeper layers of the skin may here find a favourable medium and so lead to delayed infection. The decision as to how best to deal with the blisters requires experience, but in first aid they are a self-provided dressing hardly to be improved on.

5. The degree of shock does not always correspond to the surface extent of the burn; and associated injuries when present complicate the clinical picture.

Keeping these few points in mind, certain principles of treatment become apparent. All treatment falls into three stages; the immediate or first-aid treatment; the treatment during the period of healing; the restoration of function.

**Immediate Treatment.**—In the aircraft, on the field, or even in the station sick quarters, it is well to remember that wrapping up the burn and leaving it alone may be best, as it does not compromise subsequent treatment. Clothing should be removed only if soaked in petrol or cooling-mixture; warmth, oxygen, morphia, and administration of plasma are the cardinal points in the treatment. On the exposed parts, vaseline or antburn jelly (3 per cent sulphonamide in a water-soluble base) provided in the first-aid equipment is applied.

**The Stannard Glove.**—The Stannard silk envelope designed by Bunyan, made of transparent waterproof silk fabric, can be used either as a first-aid measure or in subsequent treatment. In the form of a glove it is now carried by every member of an air-crew and is enclosed in a small first-aid pack (Figs. 11, 12). Each glove contains a weighed amount of one of the sulphonamide compounds (7.5 g. of insoluble sulphacetamide). It can be easily applied by the injured man himself and is retained in position by adhesive tape.

**Subsequent Treatment.**—There are two main principles of treatment: the closed method and the open method.

The *closed method*, be it by tannic acid, one of the dyes, or a combination of coagulants, has merits in second-degree burns, in extensive burns of the trunk, the upper arm, or the thighs; it may be a life-saving measure and as such should be employed regardless of subsequent complications—a live patient with a septic burn being at all times preferable to a corpse. The closed method, however, should have no place in the treatment of burns of the face, hands, genitalia, and perineum.

The *open method*—or treatment by vaseline gauze, tulle gras, saline packs, C.T.A.B. in lannette wax, with local application of sulphonamides—has many advantages; but experience has shown that frequent dressings are badly tolerated in the early stages and the individual needs of each patient dictate the technique of the open method in each case. Colebrook's antiseptic dressing is a cream of the following

composition : sulphanilamide 3 per cent, sulphathiazole 3 per cent, glycerin 10 per cent, castor oil 27 per cent, lannette wax 12.3 per cent, and

**The First Dressing in Hospital.**—The importance of the first dressing in hospital can hardly be exaggerated. Cleansing of the burn must be

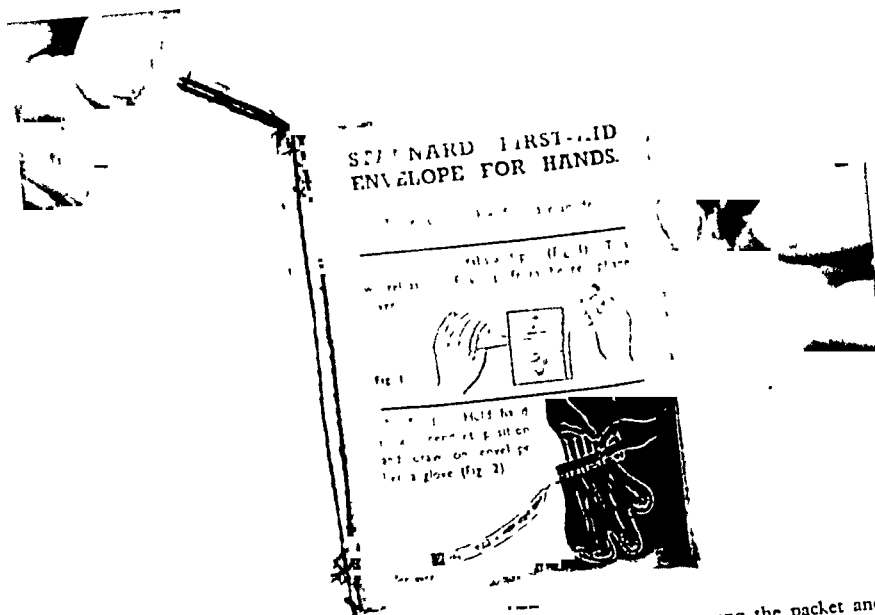


FIG. 11.—Packet containing first-aid envelope for hands. Instructions for opening the packet and for the application of the glove are printed on the cover.



FIG. 12.—First-aid Stannard sulphonamide glove. It enables the air-crew casualty to use his hand.

water. This cream can be left untouched for seven, ten, or even twelve days. It is admirable for non-infected burns, and as a first dressing. The object of treatment at this stage is to obtain epithelization or to prepare a surface suitable for grafting. The earlier the grafting the less the deformity and functional disability.

gentle ; no scrubbing, no ether soap, no trimming or débridement except of tissues already dead and loose ; blisters should not always be opened as a routine, but only if extensive, and above all no anæsthetics except morphia should be used unless associated injuries make this unavoidable. Dressings can and should be done in bed and

only exceptionally, in the presence of other injuries, is the patient taken to the operating theatre.

**Subsequent Dressings.**—These are more tedious and elaborate. In R.A.F. Burn Centres the provision of constant-temperature saline baths has facilitated the treatment at this stage. Dressings are removed painlessly or are floated off in the bath, discharges are washed away, movements of joints encouraged. At this stage of established infection routine daily dressing with sulphonamide powder (10 per cent) and vaseline gauze is the method of choice; but cases where no response to sulphonamides is obtained in a short time become sulphonamide resistant. It is here that propamidine has proved of value. But the most remarkable results have been obtained with penicillin. Flight-Lieutenant Bodenham recommends its use in the form of cream or powder in the strength of 100 units per gramme. Daily applications are necessary and lead to an early elimination of coccal infection. Success or failure in obtaining a clean granulating surface or complete healing depend primarily on factors intrinsic to the lesion—its depth, its extent, and degree of contamination—but it also depends in no small measure on such imponderable factors as the interest and enthusiasm of a young medical officer, the competence and dexterity of orderlies, and the quality of nursing. Training of orderlies, nurses, and doctors has provided the R.A.F. Burn Centres with organized team-work essential in the treatment of these lesions. The ideal team consists of a surgeon, pathologist, biochemist, physician, and a specially trained nurse and orderly.

**Treatment of Burned Hands.**—Severe burns result in contractures, the typical one being loss of flexion at the metacarpo-phalangeal joints, loss of extension at the interphalangeal joints, or, worse still, hyperextension at the metacarpo-phalangeal joints—the so-called 'frozen hand', leading to the claw-hand (Fig. 13). It is therefore of the utmost importance to preserve the position of function, called by Flight-Lieutenant Bodenham the 'basic position', throughout the period of healing and for a time after epithelization is complete. Oedema is reduced by elevation of the hands and the following position of choice adopted: dorsiflexion at the wrist, mid-flexion of fingers at all joints, and apposition of the thumb. Light aluminium splints lined with piano felt, made specially for each hand and for each individual patient, are used to maintain the position of choice; flexion or extension is obtained by elastic or whalebone, or a light metal spring attached to the splint and by a leather strap to the finger. Movements are encouraged and facilitated by immersion in baths. The patient is educated to appreciate the importance of movements and is taught the six essential movements: flexion, extension, and apposition of fingers, flexion of metacarpophalangeal and distal joints, and abduction of fingers. Plaster immobilization

is justifiable only in exceptional circumstances and then only for a short period.

**Skin-grafting.**—This should be done at the earliest possible moment; and only by a surgeon adequately trained and conversant with every

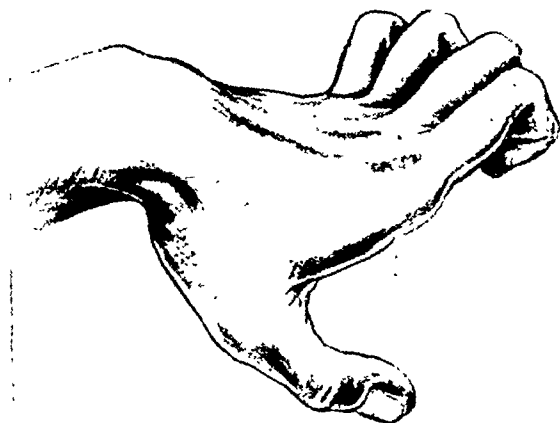


FIG. 13.—Claw-hand—the end-result of uncontrolled contraction following burns. The metacarpophalangeal joints are in extension, all other finger-joints are flexed, the thumb is in opposition. Such a hand is functionally useless. (Flight-Lieutenant Bodenham.)

detail of the special technique. Time is often saved by grafting a raw surface which *looks* clean although bacteriologically still infected. Grafts must be on a generous scale; small grafts of the eyelids, for instance, will not remedy an ectropion and inadequate grafts on the hands will not prevent serious disability, although there is no raw surface.

Reduced to its simplest terms, the treatment of burns aims at prevention of sepsis, rapid healing, correction of deformities, and restoration of function. No single method of treatment is a panacea for all cases of burns, but that skilled team work, adequate facilities, and an open mind can rescue the majority of cases and return them to a near-normal life has been abundantly shown by the number of air-crews who have returned to flying duties, including operational flying.

## WAR WOUNDS

The outstanding points in the treatment of wounds in the present war can be summarized under the four following headings: (1) The use of blood or its derivatives in the treatment of shock; (2) The control of bacterial infection by chemical means; (3) Conservatism in the actual surgical procedure; (4) The systematic use of plaster-of-Paris not only in the immobilization of fractures but in the fixation of dressings for soft-tissue injuries. As a result, the mortality among those who reach hospital has been reduced to an average of 2.5 per cent and the return to duty is estimated at 75 per cent. It is admitted that the degree of success is inversely proportional to the time between the infliction of a

wound and adequate treatment; this all-important time factor is one of the favourable circumstances in the Royal Air Force. Thus, in Bomber Command operating from Great Britain, the longest sortie does not exceed nine to ten hours, and presuming that the injury occurs over the target, a little more than four and a half to five hours will elapse before aid is reached. Those wounded on the ground in Air Force Stations are within immediate reach of the Station Medical Officer. Moreover, station sick quarters, mobile field hospitals, and R.A.F. hospitals are not, as a rule, called upon to deal at any one time with large numbers of casualties, and so the period of waiting is further reduced. These favourable conditions have dictated the policy of collecting air-crew casualties into R.A.F. hospitals at the earliest possible moment, and, consequently, there is greater clinical control of the case throughout the entire period of incapacity from operation to full rehabilitation and more rapid recovery and an early return to duty are achieved.

To illustrate the principles of the surgical treatment of war wounds, the type of injury met with, and the results of treatment, the following illustrative cases have been selected. War wounds due to enemy action, as met with in the R.A.F., can be divided into the following types: multiple foreign bodies, flak injuries, machine-gun bullets, hand grenades, and bomb explosions. The wounds differ in type according to the missiles.

#### Multiple Foreign Bodies.—

*Case 1.*—Pilot Officer, aged 20. Shot down in France in June, 1940. Multiple small wounds of the back of the neck from fragments of armour plating sheered off the Hurricane cockpit by cannon shell. First-aid treatment, antitetanic serum, and antishock treatment was given and he was transferred to England within forty-eight hours. Removal only of some of the more superficial foreign bodies was carried out. Rapid recovery and return to duty.

*Case 2.*—Group Captain, aged 42, commanding a Fighter Station in the vicinity of London. Wounded in action in November, 1940. Landed uneventfully at his own station. Multiple small wounds in the back. Transferred to an R.A.F. hospital within two hours. Explored, foreign bodies extracted, wound sprayed with sulphonamide and lightly packed with gauze. Healed in two months. Returned to duty.

*Case 3.*—Air Gunner, aged 20. Wounded in action in June, 1940. Admitted to an R.A.F. hospital the same day. Compound comminuted fracture of right forearm with numerous small metal foreign bodies. No injury to nerves or main vessels. Trimming of wound, no attempt at removal of foreign bodies, sulphonamide powder, vaseline gauze, and plaster. Returned to full duties as air gunner in six months.

#### Flak Injuries.—

*Case 4.*—Air Gunner, aged 25. In November, 1941, over Bremen, wounded by flak in left pectoral area. First-aid dressing applied in the aircraft; morphia refused. Very considerable loss of blood. Returned to home station and admitted to station sick quarters. Ragged wound over left pectoral muscles and axilla. Resuscitation: morphia, heat, transfusion

of 4 pints of stored blood. Transferred to an R.A.F. hospital within twelve hours and operated on by Wing Commander G. Morley: Wound toilet, removal of large foreign body; sulphonamide, vaseline gauze, and plaster. Plaster changed in fourteen days and again three weeks later, when the wound was healed. An arteriovenous aneurysm of the third part of left axillary artery was noticed within three months. Following manual compression of five minutes three times daily for four months, I excised the aneurysm. Uneventful recovery. Returned to operational flying ten months later.

*Case 5.*—Sergeant, aged 22. Sustained a head injury from flak on return from Essen in June, 1943. Two pieces of metal perforated the left eye, travelled across the nasopharynx, and came to rest on the right side at the level of the angle of the jaw near the carotid. No attempt was made to remove them. A third piece hit the left parietal bone, perforated both outer and inner tables, and exposed the dura mater. The parietal wound was excised, the foreign body removed, the wound sprayed with sulphonamide and sutured. Subsequently the left eye socket was reconstructed and an artificial eye fitted. He has returned to duty in less than three months.

#### Machine-gun Bullets.—

*Case 6.*—Aircraftman, aged 27. While uncoiling a belt of ammunition, one end struck the ground and one bullet exploded, entering the orbit. The nose of the bullet hit the supra-orbital ridge and was deflected downwards along the upper orbital margin. He was admitted to a civilian hospital, given first-aid and transferred forthwith to an R.A.F. hospital. The orbital tissues were explored and the bullet removed. The eye was not damaged and there is full recovery of binocular vision.

#### Cannon Shell.—

*Case 7.*—Sergeant Air Gunner, aged 23. Hit by cannon shell from a night fighter when returning from a raid on Essen. The shell hit the right foot, causing severe pain and loss of consciousness. First-aid dressing applied in the aircraft. Transferred to nearest civilian hospital as soon as the aircraft landed. The wound was cleaned and the foot put in plaster. Two days later transferred to an R.A.F. hospital. On removal of the plaster an extensive wound was found, involving the sole and outer side of the foot (Fig. 14, A). The fourth and fifth toes were gangrenous and were hanging loose, together with the tendons and metatarsal bones. The dead tissue was cut away, sulphonamide applied, and the foot put in plaster. On removing the plaster two weeks later, it was found that the wound was still dirty, but the skin over the heel and the weight-bearing part of the foot were intact (Fig. 14, B). Saline baths were instituted and sulphonamide powder applied. Within three weeks the wound was clean and a free skin-graft applied. The wound healed (Fig. 14, C) and the patient has no functional disability.

*Case 8.*—American Sergeant, aged 19. Sustained a cannon-shell wound of the chest in a daylight raid on Paris in April, 1943; admitted three hours later to an R.A.F. hospital in England, in extremely shocked condition from severe loss of blood. The co-pilot, a medical student, applied sulphonamide to the wound and dressed it. X-ray examination revealed a non-exploded cannon shell beneath the right clavicle. The lung fields were clear and the heart shadow was not displaced. There was a large ragged wound,

2 in.  $\times$  4 in. over the upper part of the sternum; the wound was bleeding profusely. The inner half of

sternomastoid muscle was torn and a portion of it was missing. He was operated on by Squadron-Leader



FIG 14—Cannon-shell wound of foot. A, 2 days after injury, B, 14 days later before grafting, C, 1 month after grafting. (Squadron-Leader D. N. Matthews.)

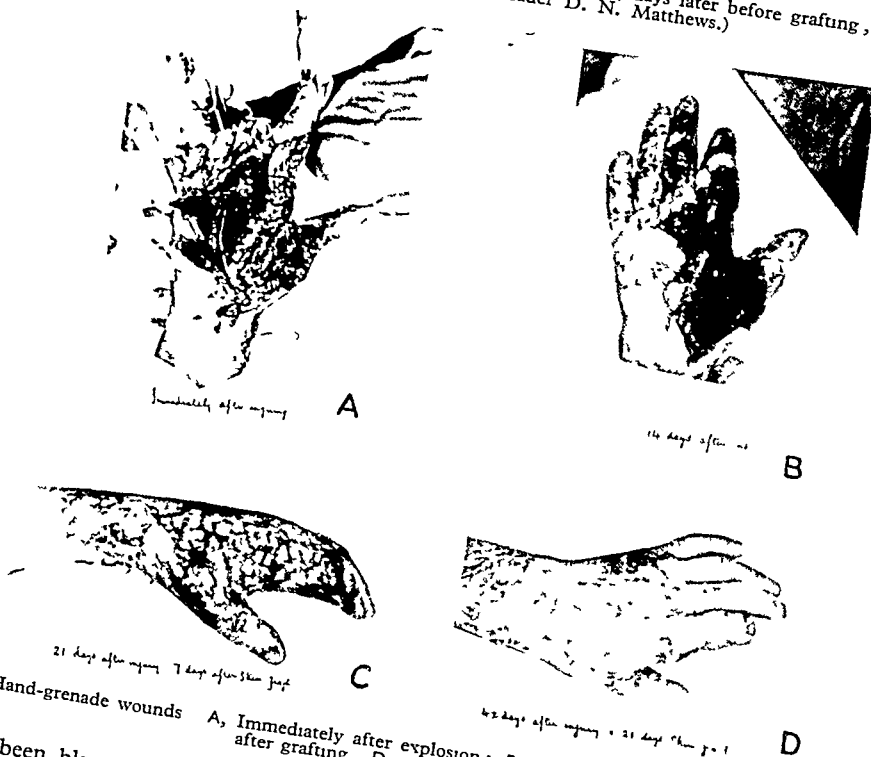


FIG 15—Hand-grenade wounds A, Immediately after explosion; B, 2 weeks later, before grafting, C 1 week after grafting, D 42 days after injury

the clavicle had been blown away and most of the manubrium sterni was missing, revealing the great vessels and upper part of the pericardium. The

D. N. Matthews. Haemorrhage was controlled by gauze packing and a 5-pint transfusion of stored blood given. The unexploded cannon shell was removed

under local anaesthesia and handed to the Bomb Disposal personnel. It was noticed that a hiss of air escaped as soon as the tissues overlying the shell were cut. The patient remained unconscious during the next ten days and had to be fed by a nasal tube. There was a severe bruise over the occiput, which probably accounted for the cerebral contusion. Each time the pack was removed from the sternal wound for the application of sulphonamide powder, brisk hæmorrhage recurred. On the tenth day, under a general anaesthetic, the wound in the neck and chest was explored by Mr. Tudor Edwards; a tear was found in the internal jugular vein at its junction with the right subclavian. A portion of the jugular was removed and the ends ligatured. The wound healed satisfactorily. The wound was repatriated to America in a plaster spica.

#### Hand Grenade.—

*Case 9.*—Flight Lieutenant. This officer was demonstrating the mechanism of a hand grenade when it exploded, inflicting an extensive lacerated wound on the dorsum and palm of the hand (Fig. 15, A). Four hours later the wound was trimmed, cleaned, dusted with sulphonamide powder, covered with vaseline gauze, and put in plaster. The hand was elevated for the next fortnight, the plaster was then removed, and a clean granulating surface found (Fig. 15, B). Immediate grafting was done by means of a sheet of Thiersch graft cut into small squares and placed  $\frac{1}{8}$  in. apart; a fresh plaster was applied. This was changed at the end of one week, when the grafts were found to have taken, their edges coalescing (Fig. 15, C).

#### Bomb Explosions.—

*Case 10.*—Group Captain, aged 29. This officer, commanding a Bomber Station, was running towards an aircraft which had crashed on taking off with a 4000-lb. bomb aboard. Knocked down by the blast of the explosion, he was hit by a large fragment which nearly severed the right arm below the shoulder, another fragment caused a perforating wound of the knee-joint. First aid and resuscitation were given at the station sick quarters; the transfusion was continued in the ambulance during the transfer to an R.A.F. hospital. The right arm was amputated; the wound in the knee cleaned, trimmed, and sprayed with sulphonamide; the leg was put in plaster. This officer returned to duty three and a half months later and has since rendered distinguished services as officer in charge of a 'clutch' of operational bomber stations.

**General Principles of Treatment.**—The above 10 cases illustrate the types of war wounds inflicted by different missiles as seen in R.A.F. casualties. The principles underlying treatment can be summarized as follows:—

*Resuscitation* is of paramount importance. It takes precedence over treatment of wounds, with the exception of control of hæmorrhage. Warmth, sedatives, oxygen, and fluids require no emphasis. Often these remedies alone suffice; but pronounced or severe states of shock invariably require in addition intravenous medication with blood or plasma. In burns in particular, plasma is the fluid of choice as the hæmo-concentration is a contra-indication to the administration of whole blood. In shock resulting from or concomitant with hæmorrhage, fresh blood or stored

blood is indicated. The total amount needed and the rate of administration vary with the injuries sustained, the degree of shock, and the time elapsed since infliction of the wound. One or two pints may suffice to raise the blood-pressure to 110 mm. Hg or more, but if need be 4 to 6 pints can be given, the amount being controlled by the blood-pressure readings and general clinical observation. Resuscitation has achieved its object when the injured is fit for operation. No time should be lost in performing the necessary operative procedures as otherwise secondary shock may occur.

*Chemotherapy.*—The control of bacterial infection by chemotherapy is so great an achievement as to overshadow almost all medical advances in recent years. Systemic chemotherapy is well established in many conditions, both medical and surgical. The more recent advances concern the local antiseptic treatment of wounds. The success of local application is due to the great concentration of the drug. Of the three compounds most commonly used—sulphanilamide, sulphapyridine, and sulphathiazole—the latter combines the highest dissolved concentration with persistence of effect. The greatest value of the local application of sulphonamides is the *prevention* of infection. To overcome established infection, when treatment by sulphonamides has failed, two other chemical substances have been used with some success—proflavin in powder form, not in solution, and propamidine in a water-soluble base. Both substances have proved successful in some cases of wounds and burns when sulphonamides have failed; but the most remarkable substance of recent application is penicillin, which has been appropriately termed a 'biological antiseptic'. It was first used in the R.A.F. in June, 1942, in a case of severe staphylococcal septicæmia following osteomyelitis with a dramatic recovery of an apparently hopeless case. It has successfully controlled staphylococcal septicæmia, possibly the only substance so far to do so; it succeeds where sulphonamides fail. It can be used locally or systemically—it promises to open a new era in the control of infections. Much work in many fields is yet needed to establish the relative merits of these various substances, but this much is certain—that prevention of wound infection is possible and chronic suppuration of wounds is by no means inevitable.

Penicillin is likely to alter the established principles of the treatment of war wounds. Whereas with sulphonamides it is a cardinal principle that war wounds must not be primarily sutured, with penicillin closure of the wound, even when infected, is permissible and sometimes essential. Healing of such wounds is clearly an indication that penicillin is likely to alter our conception of what are sound surgical principles.

*The Surgical Treatment of Wounds.*—Adequate surgical treatment of wounds remains the most important part of the treatment. The use of sulphonamides and of penicillin does not replace it; it does,

however, influence the technique of the treatment. The surgeon dealing with a war wound should appreciate the difference between such wounds—which are almost bound to become infected—and wounds seen in peace-time. The actual method of dealing with the wound depends upon the time elapsed since its infliction. Up to eighteen hours—at most twenty-four hours—a wound may be contaminated only; beyond that limit of time it should be considered as infected. All wounds are in need of an initial surgical toilet; in the early stage, *excision* of the wound may be possible and advisable, later on it is still possible, but no longer desirable, and the surgeon must guard against surgical intervention lapsing into surgical interference. When the time for excision has been passed, there is still time for *débridement*; later still trimming, drainage, and counter-drainage only may be permissible. Excision, *débridement*, or trimming must always be purposeful, adequate, and gentle; only dead, loose, dirty tissue should be excised; vessels and nerves must be respected; the skin spared as much as possible; foreign bodies—missiles, clothing, and loose pieces of bone—should be removed. Adequate exposure of the whole wound is essential and this should be achieved by enlarging the wound in its long axis and exploring all the planes of tissue involved. Of all the tissues, muscle should be excised most adequately. *Primary suture of war wounds should never be done unless penicillin is available.* If the wound remains clean, secondary suture within four or five days can be carried out.

*Dressing of the Wound:* Hæmostasis having been achieved, the wound is powdered or rather 'frosted' over with sulphonamide. The dressing of choice is vaseline gauze; this is neutral to sulphonamide, non-irritating to the tissues, permits drainage, and protects the surrounding skin. This dressing is kept in position by two slabs of plaster or a complete plaster cast which should include the joints proximal and distal to the wound, so ensuring complete immobilization.

*Indications for Amputation:* Only when survival of a limb is out of the question owing to injury to the main vessels or in the presence of established gangrene, is primary amputation indicated. Every effort to save a limb is worth while, but judgement and experience are needed not to attempt to do so at the risk of losing the patient. Amputation stumps in war wounds should be treated as wounds and no primary suture attempted. Conservatism in the matter of amputation was dictated in the R.A.F. by the frequency of multiple severe injuries. When two limbs or sometimes three are the seat of severe trauma, amputation is not unnaturally postponed. The fact that R.A.F. casualties reach R.A.F. hospitals *early* has no doubt contributed towards this conservatism, which in the end showed some remarkable recoveries.

The cardinal principles of surgery of war wounds can be summarized in four words:

resuscitation, *débridement*, chemotherapy, immobilization; and the surgeon who deals with war wounds should constantly remember that to achieve success he should: excise—conservatively; drain—adequately; immobilize—completely; and rehabilitate—early.

### FROST-BITE

The problem of frost-bite as affecting the flying personnel of the R.A.F. has been solved in practice by preventive measures. Frost-bite conditions exist at a temperature of  $-20^{\circ}$  C. and below. The fall of temperature in relation to altitude is computed to be approximately  $1^{\circ}$  C. for every 500 ft.; it is therefore possible to estimate the probable temperature likely to be encountered at any given altitude. The crews of Bomber Command operating from Great Britain are submitted to frost-bite conditions throughout the whole year, and for a period of seven or eight months extremely low temperatures are met. The problem was therefore of considerable practical importance, as the victims of frost-bite were lost to operational duties for various periods of time and sometimes altogether.

**Clinical Considerations.**—Frost-bite affects the hands and fingers, the feet and toes, the face, or a combination of sites. It not infrequently results from touching metal parts with bare hands. According to the degree of injury the lesions can be subdivided into three groups: slight, moderate, and severe. The *slight* cases are those where the numbness, anæsthesia, and pallor or greyiness of skin regress with only slight shedding of the most superficial layers of the skin; at this stage the damage is still a reversible reaction, death of tissue has not occurred; about 30 per cent of cases classified officially as frost-bite fall into this group. In the *moderate* degree, blistering follows within a period of twelve hours or more (Figs. 16, 17), but the capillaries and arterioles respond to treatment, circulation is restored, and only little of the superficial tissue is lost; this group accounts for 45 per cent of cases. Seventy-five per cent of all cases of frost-bite in air-crews are therefore mild and recover rapidly. The remaining 25 per cent of cases are *severe* and result in gangrene, aggravated by infection, with consequent loss of fingers or toes, prolonged periods of incapacity, permanent damage to the skin, severe hyperhidrosis, and trophic changes in the skin and nails. The conditions under which frost-bite occurs are illustrated, in the very brief histories of the following cases.

#### Slight Cases.—

*Case 1.*—Wireless Operator, aged 22. In December, 1939, flying at 23,000 ft., took off gloves to adjust wireless; on return noticed that the fingers were cold and anæsthetic. A few blisters formed the following day. Healed and returned to duty in twelve days.

*Case 2.*—Air Observer, aged 21. In December, 1940, flying at 17,000 ft. over North Sea; temperature  $-32^{\circ}$  C. He was wearing three pairs of gloves, silk, wool, and leather. Tips of most fingers became numb,



anæsthetic, and blue. Rapid recovery. Return to duty in fourteen days.

**Case 3.**—Wireless Operator—Air Gunner, aged 22. In January, 1942, flying at 17,000 ft., temperature  $-32^{\circ}\text{C}$ ., handled a metal flash bomb for ten minutes. On return to Base, the right hand was bluish and the little finger was swollen; blisters developed the next day. Healed rapidly.



FIG. 16.—Frost-bite. Moderate degree. Œdema, early blistering, and hæmorrhage.

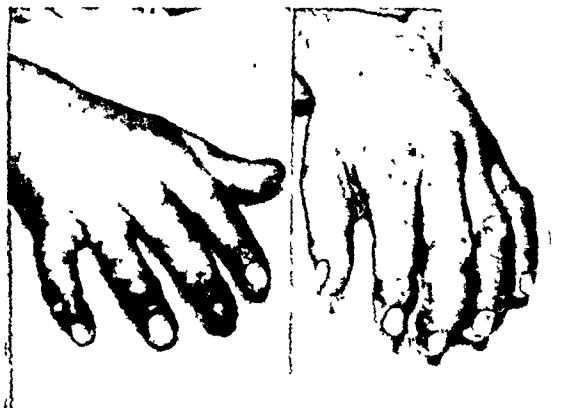


fingers were numb, but he felt no pain and was not aware of the cold. Severe frost-bite, with loss of skin; raw surfaces healed in four months; mobility of fingers impaired.

**Case 7.**—Wireless Operator—Air Gunner, aged 21. In December, 1940, flying at 23,000 ft.; temperature  $-50^{\circ}\text{C}$ . Noticed coldness and numbness of fingers for one to two hours before descent. Frost-bite with



FIG. 17.—Same case as Fig. 16, 48 hours later. Marked increase in size of blisters and hæmorrhage in smaller blisters. This case made a good recovery.



#### Moderate Cases.—

**Case 4.**—Second Pilot, aged 20. In November, 1940, was instructed to hold a flare in the chute until told to drop it. This resulted in the exposure of hands to the outside air for twenty minutes; temperature  $-20^{\circ}\text{C}$ . Two pairs of gloves worn. Moderate degree of frost-bite developed in all fingers; recovery in five weeks.

**Case 5.**—Air Gunner, aged 21. In rear-gunner's turret for four hours on the night of Jan. 21, 1942, mostly at 10,000 ft. Feet cold most of the time. On return noticed that the fingers were cold, white, and anæsthetic, and the toes bluish, swollen, and painful. Blisters developed within fourteen hours; eventually lost most of the nails. Recovered in three months.

#### Severe Cases.—

**Case 6.**—Air Gunner, aged 23. In December, 1939, was in the rear turret at 18,000 ft. for two hours. Took off gloves for half an hour to adjust guns. The

subsequent loss of two fingers, and loss of nails and trophic changes of skin. Ten months off duty.

**Case 8.**—Air Gunner, aged 21. In October, 1941, during a six-hours' sortie, mostly at 18,000 ft., removed gauntlets several times to adjust helmet. Severe frost-bite developed, gangrene of terminal phalanges of two fingers and permanent disability from trophic changes and fixation of joints.

**Causative Factors of Frost-bite in Air-crews.**—A study of the various factors reveals that the most vulnerable member of the crew is the rear gunner, more than 53 per cent of cases of the series occurring in rear gunners; the next in frequency is the wireless operator and the other gunners. In most cases exposure of the hands was deliberate and thoughtless; mechanical failure of oxygen supply or of the heating accounts for some of the cases.

**Incidence.**—During the four years of war the incidence of frost-bite has greatly decreased. The decrease is not only relative to the number of personnel and sorties, but is absolute. In the latest period from October, 1942, to March, 1943, in the Bomber Command personnel operating from Great Britain, the incidence varied from 0.015 to 0.02 per cent, a truly negligible figure.

**Prevention of Frost-bite in the R.A.F.**—The remarkable reduction in incidence amounting to virtual abolition of frost-bite in air-crews was achieved gradually by preventive measures, education, and technical improvements. Heating of aircraft, provision of electrically heated clothes (gloves, stockings, and waistcoats), and improved oxygen equipment are the most important factors, but in addition education of air-crews by the Squadron Medical Officers, valeting of flying clothes, and testing of electrical connexions and oxygen apparatus on testing panels installed in the crew rooms have reduced to a minimum the preventable accidents.

**Treatment.**—A study of records shows that rapid progress was made in the methods of treatment. Rubbing with oil or turpentine soon gave place to painting with coagulating dyes; this, in turn, was replaced by sulphonamide powder and cotton-wool packs. The recent experience in the Royal Air Force supports the view that elevation of the limb, avoidance of trauma, and *cooling* of the affected parts leads to the minimal loss of tissue, absorption of blister fluid, and reduction of œdema. Cooling of the frost-bitten part can be achieved by means of ice packs, a stream of cold air from a fan, or iced saline packs, but, better still, by simple exposure to room temperature. It should be emphasized that recovery with trivial loss of tissue can only be achieved if the case is slight or moderate in degree and treatment given early. Gangrene and infection, once established, must be treated on general surgical principles.

### IMMERSION INJURIES

These injuries result from exposure to sea water and the effects of cold. They occur in R.A.F. personnel, who, after 'ditching', remain for some time in a dinghy, and also as the result of torpedoing of ships. The general effects of exposure, the concomitant shock, and the degree of damage due to immersion depend mainly on the temperature of the water, the length of exposure, and to associated trauma. The feet, ankles, and legs are most commonly affected, but similar changes in the hands are well known. The main clinical features are swelling, numbness, tingling, loss of sensation, and desquamation. Impaired circulation is shown by bluish discoloration of the affected limbs; later erythema occurs, and this is accompanied by increased swelling and pain. The vascular changes show the cycle of vasoconstriction followed by vasodilatation. The painful stage occurs with the return of circulation and lasts a short time only.

Blister formation is occasionally seen. The effects of exposure are aggravated by the incidental injuries such as bruising of the skin, sprains, and effusion of blood into muscles or joints. In cases rescued within six to twelve hours the recovery is rapid and no permanent disability results. In more severe cases neuritis, excessive sweating, trophic changes of the skin and nails, and persistent tenderness, especially of the soles of the feet and the palms of the hands, are the usual delayed effects. If the exposure is prolonged and the weather conditions bad, the circulatory changes may be so severe that gangrene of toes, fingers, feet, or hands may follow. There is clear evidence of the protective value of clothes, socks, flying boots, gumboots, etc. The mild cases recover in ten to fourteen days; the average stay in hospital is three to five weeks, but in severe cases return to duty is delayed for periods up to six months. Treatment is similar to that in cases of frost-bite. It consists in general measures to combat shock: elevation of the affected limbs, cooling by exposure to room temperature, and surgical cleanliness.

### HEAD INJURIES

A study of head injuries sustained in flying by members of air-crews reveals some interesting points. During the first two years of the war, 1545 cases were recorded; and the available data were analysed. The cases were divided into five groups: (1) Multiple injuries and head injuries; (2) Head injuries only; (3) Maxillo-facial injuries; (4) Head and maxillo-facial injuries; (5) Head injuries with fracture of one or two other bones. This classification showed the following:—

1. That head injuries alone or in association with multiple injuries account for three-quarters of the cases (1116 fatal and non-fatal cases).
2. That maxillo-facial injuries are relatively few; 162 of the total of 1545 cases.
3. That the combination of head and maxillo-facial injuries was equally small, 166 of a total of 748 survivals.
4. That none of the maxillo-facial injuries proved fatal.

The end-results of cases of head injury can be expressed axiomatically by the law of 'all or nothing'; thus, *if a case of head injury escapes death, the injury is such that return to full flying duties can confidently be anticipated*. From the earliest days of the war, provision was made for the rapid segregation of air-crews suffering from head injuries, and their transfer to special centres dealing exclusively with head injuries or maxillo-facial cases. This ensured early and highly skilled specialized treatment, with the result that 74 per cent (553 cases) of survivors returned to a full flying category and the majority of these did so in a period of two months or less.

**Type of Injury.**—Head injuries fall into two main groups: (1) Fatal; (2) Non-fatal—about equal in number. These groups represent two

different clinical entities having no common denominator. Thus, most cases of *fracture of the skull*, especially in association with multiple injuries, resulted in death; of 820 cases of fracture of the skull only 55 cases, or 6.5 per cent, survived, whereas *all* the cases of concussion lived. The figures indicate that the kind of accident that leads to either a fracture of the skull with other injuries or a double fracture of the skull alone, is indeed almost invariably fatal; but a single and uncomplicated fracture gives a reasonable chance of recovery, for of 58 fractures of the vault 38 survived. The severity of injury is also shown by the fact that 83 per cent of the fatal cases die immediately, that is, they are dead when taken from the aircraft or when found. In contrast to the fatal head injury, the non-fatal group is characterized by the very small number of fractures of the skull, most cases coming under the heading of concussion, scalp wound, or maxillo-facial injuries.

**The Fate of the Survivors.**—The total number of survivors, 748 cases, were studied from the point of view of their return to flying duties and their degree of usefulness as members of an air-crew. The wastage of personnel amongst survivors from head injuries is surprisingly small and the return to a full flying category the rule rather than the exception. Of 748 survivors no less than 553, or 74 per cent, returned to full flying duties; this figure is the lowest limit, as 79 cases had not been determined at the time of the investigation, and some of these would normally return to flying.

**The Rate of Recovery.**—Most cases of head injuries usually recovered in less than two months. Scalp wounds, laceration of the face, and fractures of the nose show the quickest recovery. The return to duty following head injury after a comparatively short period of incapacity compares favourably with the end-results of other injuries.

### ORGANIZATION OF SURGICAL SERVICES IN THE R.A.F.

The Surgical Services of the Royal Air Force aim at the provision of all specialized treatment within the R.A.F. and in a few selected civilian centres closely associated with its medical services. It embraces the whole field of treatment from the collection of casualties, the provision of first aid, the maintenance within the R.A.F. hospitals of specialized centres for those types of injuries requiring specialist treatment, to full rehabilitation and accurate assessment of the degree of fitness for flying at the termination of treatment and a complete follow-up system till a permanent flying category is reached.

**Collection of Casualties.**—Towards the latter part of the period of the Battle of Britain, the Air Ministry reached the decision that air-crew casualties in England and Wales should be collected and transferred into R.A.F. hospitals at the earliest possible moment. Experience

during the subsequent three years fully justified the wisdom of this decision both as regards the individual casualties who received all their treatment under one authority, and as regards the Service as a whole, as it ensured the earliest return to flying duties and the best use of the personnel. To ensure a steady collection of air-crew casualties in the United Kingdom a system of notification was established. It embraced all possible locations of the casualties and the notification was sent by the quickest possible route to the Central Medical Establishment of the Royal Air Force. R.A.F. Medical Officers on becoming aware that an air-crew casualty had occurred, forwarded the notification indicating the location of the casualty, the nature and degree of injury, and whether sustained in flying, in action, or otherwise.

Arrangements were made with the Admiralty and the War Office for naval and military hospitals to notify the R.A.F. Central Medical Establishment of the admission of all air-crew casualties. Full co-operation of the Ministry of Health and of the Home Office was obtained and the admission of an air-crew casualty to a civilian hospital was notified through the local police to the nearest R.A.F. station, who, in turn, forwarded the information to the Central Medical Establishment.

The Casualty Collection Department of the Central Medical Establishment was available day and night for the receipt of notifications. All the data were checked against information received from other sources and by direct contact with the hospital where the casualty was located. The decision as to the need and appropriate time of transfer of a casualty to an R.A.F. hospital depended upon the type of injury, the fitness for transfer, and the location of the casualty. In cases of doubt the patients were visited by an R.A.F. consultant or specialist. Eventually, nearly all air-crews were transferred and orthopaedic cases, burns, head injuries, and chest injuries were speedily segregated into specialized centres. The transfer was made by road, rail, or air, according to circumstances; as time went on more and more use was made of air ambulances in suitable cases.

**Provision of First Aid.**—In single-seater aircraft first-aid outfits were provided in small bulk carried by the pilot, generally on the parachute harness; in multi-seater aircraft more elaborate outfits were installed in positions accessible to different members of the air-crews. These outfits contained only such necessities as could be used by the air-crew themselves; this, however, included anti-burn jelly, morphia, and a tourniquet in the use of which the air-crews were instructed by the Squadron Medical Officers.

**Station Sick Quarters.**—On operational stations, the provision of surgical aid was installed in the decontamination centres. These blast-proof and gas-proof buildings, together with the adjoining 'Sick Quarters' with which they communicated, were miniature hospitals.

Tiers of bunks were installed and the adjoining walls piped for oxygen, so that each bunk had its own oxygen delivery point flow-meter and mask. Oxygen was delivered from a battery of cylinders, and spare cylinders, generally of the aircraft type, provided. Each bunk was fitted with an electrically heated blanket or a heat cradle, a switch panel of the wall allowing the individual control of each cradle. Supplies of blood, plasma or serum, sterile distilled water, the necessary transfusion apparatus, were at hand, always ready for use. Surgical equipment necessary for emergency treatment—arrest of hæmorrhage, tracheotomy, drainage of cavities—splints, plaster, and dressings, completed the equipment. In addition, a few stretchers were fitted with their own oxygen apparatus (cylinder, pressure gauges, economizer, and mask), and in some ambulances provision was made for transfusion of blood. The Station Medical Officers were thus provided with all necessities for resuscitation and first aid, and good use was made of these facilities not only for the casualties returning from operational sorties, but also in case of enemy attack on the station.

In addition, mobile surgical teams for general surgical aid, and for orthopædic and maxillo-facial cases, were located at a few selected stations. These teams were primarily intended to proceed to the scene of the accident, but use was made of them on occasions to assist small hospitals after air raids.

### SPECIAL CENTRES

The frequent occurrence of a certain type of injury in air-crews led to the development of special centres. For these, special equipment was provided, selected medical officers appointed, and orderlies trained. A high degree of specialization was achieved, with consequent diminution in morbidity, a more rapid functional recovery, and an earlier return to flying duties.

**Burn Centres.**—Five burn centres were established in R.A.F. hospitals and one in a civilian hospital under the personal direction of Mr. A. H. McIndoe, the civilian Consultant in Plastic Surgery. The complex problem of the treatment of burns required the use of special laboratory facilities, burn wards, constant-temperature saline baths, operating theatres reserved for plastic surgery, and facilities for recreation of patients requiring prolonged hospitalization. The young medical officers in clinical charge of these departments were chosen for their special skill, knowledge, and interest in burns and plastic repair. No facility was denied to them, and the guidance, advice, and example of Mr. A. H. McIndoe was constantly at the disposal both of the air-crews and to last, however long and complicated the treatment, air-crew victims of burns will find within their own hospitals all that surgery can achieve.

**Maxillo-facial Units.**—These units are generally associated with the burn centres and plastic surgery departments. In addition to

medical officers, dental officers have been specially trained, and dental laboratories and workshops provided, and cases are transferred to such units at the very earliest moment.

**Fracture Departments.**—The segregation of all fractures into fracture wards under trained orthopædic surgeons, the transfer of air-crews to these centres, and the creation of an elaborate and highly efficient orthopædic organization is primarily the result of the relentless labours of Mr. Watson-Jones. This organization, with its wards, plaster-rooms, X-ray facilities, detailed record keeping, deals with a vast number of cases. Its achievements consist not only in the actual treatment of fractures with the concomitant improvement in results and shortening of the period of incapacity, but equally in the pure surgical advances. Although fractures in the R.A.F. air-crews do not differ from those met in other Services in war-time, some fractures are commonly the result of flying accidents, and certain injuries are more frequent than in other Services. Multiple fractures are common; three or even four distinct injuries may be found in the same patient. Fractures of the talus with associated injuries of the ankle-joint, fractures of the spine, injuries of great severity with association of fragments are met with frequently. The severity and multiplicity of injuries has of necessity led to a greater conservatism in treatment than would have been the case if solitary injuries only had had to be dealt with. That this segregation has been justified is illustrated in a report by Wing Commander W. D. Coltart on a series of over 600 cases of fracture of the tibia and fibula and of the femur. A critical analysis of the cases leads him to conclude that "These fractures have on the whole united more quickly than those transferred from other centres, especially if transferred more than fourteen days after injury. The early transfer of these fractures should therefore be insisted upon." In fractures of the talus with associated injuries of the ankle, the immediate treatment is even of greater importance, and such injuries must be considered as first emergencies if functional recovery with minimum disability is aimed at.

**Rehabilitation Centres.**—Special centres for rehabilitation for air-crews have been established. Besides physical rehabilitation, facilities are provided for technical rehabilitation, facilities centres are equipped with gymnasiums, playing fields, swimming pools, and tennis and squash courts. Physical training instructors and medical officers receive the patients on their discharge from hospital, nearly always still encased in plaster. They are taught to walk, to run, to dance, to use their muscles, to discard crutches, sticks, plaster casts, and the self-consciousness of their disability. Systematic and graduated exercises lead to physical recovery. During the period of recovery

technical rehabilitation is commenced as soon as the physical condition permits. Pilots fly in a Link Trainer, navigators, bomb-aimers, wireless operators, air gunners, flight engineers are provided with the elaborate and intricate instruments of their speciality. The value of the technical re-education at this stage is both physical and psychological. The air-crew become aware that they are again air-crews and no longer patients or cripples.

**Assessment of Fitness for Flying.**—All air-crews, injured or otherwise incapacitated, pass through a Board before returning to flying duties. The degree of disability is estimated in its relationship to their flying duties. Cases of frost-bite, burns, or other vascular disturbances are reviewed with the possible effects of altitude or cold on their previous injuries. If the physical disability leaves a doubt as to their safety or efficacy in the air—a report is obtained from the executive as regards the particular point in doubt.

### SUMMARY

The scheme of surgical treatment from the time of injury in the aircraft to the final disposal

and return to duty has been indicated. Facilities provided by the Royal Air Force in special surgical departments exceed even those of teaching hospitals in peace-time. These facilities and the selection of specialized staff have contributed to the advances made in the treatment of injuries of all kinds. The guiding principle is to provide air-crews with the best possible treatment, particularly in the case of injuries resulting from flying and enemy action. The final aim and object is to obtain the maximum operational efficiency in the shortest possible time.

I record with grateful acknowledgement my indebtedness to Air-Marshal Sir Harold Whittingham for many facilities without which this paper could not have been written and for permission to publish it. My thanks are also due to Dr. Bradford Hill for revising the statistical data of the section on head injuries; to Wing Commander G. Morley, Squadron Leader D. N. Matthews, and Flight Lieutenant Bodenham for the clinical notes of some of the case records, and for some of the illustrations.

## THE TREATMENT OF BURNS AND WOUNDS WITH SKIN LOSS BY THE ENVELOPE METHOD\*

By R. P. OSBORNE

IN July, 1941, there were published in the *British Medical Journal* four articles on "The Treatment of Burns and Wounds by the Envelope Method" (Bunyan, J.; Hudson, R. V.; Pearson, R. S. B., et al.; and Hannay, J. W.). Since then little has appeared in the literature on the subject: the object of this paper is to set forth some personal observations following upon the employment of this method on cases admitted to the Plastic Surgery and Jaw Injury Service of the Stoke Mandeville Hospital.

Envelopes have been used on 31 cases in nine months. The cases fall into three groups:—

- |   |    |
|---|----|
| 1. New burns—i.e., within 48 hours of the injury    | 6  |
| 2. Old burns  | 12 |
| 3. Unhealed wounds with skin loss of varying degree | 13 |

The numbers are too small to tabulate results, but several illustrated cases will be described.

### OBJECTS OF TREATMENT

The objects of treatment are: (1) To prevent infection and cross-infection; (2) To obtain a skin covering as soon as possible; (3) To eliminate pain; (4) To prevent deformity; (5) To maintain free function; (6) To reduce to a minimum the length of time between receipt of injury and return to normal duty.

Our experience shows that the envelope method fulfils these objects in a praiseworthy manner.

1. Whenever hæmolytic streptococci were present in the lesion at the time of applying the envelope, these disappeared. In some cases the aid of sulphanilamide insufflations was required.

In one instance (*Case 6*) when the envelope was removed before healing was complete, hæmolytic streptococci reappeared. There was not a single case of hæmolytic streptococci appearing in an envelope when it was known to be absent at the time of application.

2. In cases without full-thickness skin loss, healing was obtained in the envelope except in one or two instances, when small areas remained unhealed. Where there was full-thickness skin loss epithelialization has been greatly assisted: small areas of third-degree burns have healed completely. Large areas of skin loss have been rendered suitable for skin-grafting immediately, after which the envelope method has been continued.

3. The relief of pain has been dramatic. Young patients have been admitted terrified at the thought of having their dressings changed: envelopes have been applied and within one or two days at the most these patients have been free from pain and confidence has been re-established; their outlook has changed and the general condition has already begun to improve.

4. There has not been in this series a single instance of deformity arising during treatment in an envelope.

\* From the Plastic Surgery and Jaw Injury Service, Stoke Mandeville Hospital, Aylesbury.

5. In limb lesions 100 per cent function was regained in all cases except one (*Case 10*), where there was long-standing ankylosis of the ankle prior to the application of the envelope.

6. Rehabilitation treatment was given to all the cases and at the time of discharge they were fit to resume their normal duties. The time spent in hospital compares most favourably with other methods of treatment.

### TECHNIQUE

**Sterilization of the Envelopes.**—The new tie-on type of Bunyan-Stannard envelope has been used throughout (except for the smock in *Case 2*). It was decided to make efforts to sterilize the envelopes, because: (a) When taking smears from the inside of the envelopes as supplied and before use, the *Staph. albus* had been found on more than one occasion. Since these organisms can be found, it is reasonable to assume that the streptococcus also might survive in the envelope. (b) Having taken every precaution to render the wound as clean as possible, it is just as fitting to apply a sterile covering as to apply a sterile dressing in other methods.

Simple soaking of the envelope in strong solutions of Milton prior to application of the bag does not always get rid of the *Staph. albus*, and it was therefore decided to attempt dry sterilization. The means employed was 10 lb. steam pressure for ten minutes in the hospital autoclave ordinarily used for the sterilization of rubber gloves.

The envelopes were considered to be too tightly folded and in too numerous folds as supplied in their cellophane covers. These latter were therefore discarded and the envelopes fully opened out and then folded three times. One of these was then placed, together with a test packet containing strains of *B. subtilis* (as used by the L.C.C.) in a linen bag similar to those used in most E.M.S. hospitals for the sterilization of gloves and dressings. After ten minutes in the autoclave it was found that the *B. subtilis* had been killed. The next stage was to fold a dozen envelopes in the same manner and place these in a canvas bag. Test packets of *B. subtilis* were used: (a) Two at each end of envelopes 1, 6, and 12; (b) One between envelopes 6 and 7; (c) One under the flap of the canvas bag.

This test showed that the *B. subtilis* was not killed. It was repeated in exactly the same way except that wherever a test packet of *B. subtilis* was placed another containing *Staph. aureus* was used. The result of this was that the *Staph. aureus* was killed in every packet, but once more the *B. subtilis* escaped.

We were advised by a pathological colleague that the killing of the *Staph. aureus* could be safely taken as indicative of satisfactory sterilization.

#### Effect of Sterilization upon the Envelope.

—Observations were made as follows:—

a. The material became slightly yellower, but this did not interfere with its clarity.

b. Repeated sterilization produced a deeper yellow colour and the clarity was slightly reduced each time.

c. The seams remained intact.

d. The texture remained unaltered.

e. Seamed edges tended to adhere to each other, calling for delicate handling when applying the envelope if tears were to be avoided. To overcome this, grease-proof paper was inserted between the folds and this measure was a success. Particular care is necessary to avoid adhesion of the tying-on slips to seams, for the former are readily torn.

f. The inner surfaces tended to adhere in a patchy manner, but this is avoided by inserting a layer of grease-proof paper into the envelope.

g. The inner surfaces of the inlets and outlets became adherent and this proved to be a tiresome complication, because of the time which had to be spent in a careful separation of the edges with forceps before the glass tubing used for irrigations could be inserted. To overcome this the adhesive seals already applied by the manufacturers were removed and the inner surfaces of inlets and outlets well powdered before sterilization. In removing the adhesive seal, some of the adhesive material was left on the outer surface of the inlets and outlets; in order to prevent these areas adhering to other parts of the envelope in folding, they were cleansed with ether.

**Storage of Sterilized Envelopes.**—With the knowledge that at any time with short notice several cases of burns might be admitted, it was considered that a store of already sterilized envelopes should be available immediately on demand. To keep them in the canvas bag was not considered wise, for quite apart from putting a number of bags out of circulation for an indefinite period, they are not sufficiently air-tight and are not easily stored. To overcome these objections a layer of grease-proof paper was placed inside the envelope (*f*, above) and one on each side, so that when the envelope was folded into three, no two surfaces of the envelope came into direct apposition with each other. The envelope was then loosely tied with cotton to keep the paper in place and the type of packet written on the paper.

After sterilization the envelopes were inserted into previously sterilized paper envelopes large enough to make insertion an easy procedure. The paper envelope was now sealed and the type of envelope it contained recorded on the outside. The insertion was carried out by a member of the theatre staff who had 'scrubbed up' and donned the usual cap, mask, gown, and gloves.

By this means a considerable number of envelopes can be stored in a small space, amply justifying the time and trouble involved, which is always much less than the description suggests.

**Steps in the Technique of Application of the Envelopes.**—The general treatment follows the usual lines and will not be discussed here. An anæsthetic is usually given for the application of

the first envelope: gas and oxygen or some other form of light anaesthesia is sufficient.

1. Arrange mackintosh sheeting as a gutter underneath the area to be treated so that the fluid can readily flow into a receptacle.

2. Remove dressings previously applied.

3. Photograph.

4. Take smear from wound and send for bacteriological examination.

5. Under a continuous stream of 1 per cent electrolytic sodium hypochlorite in tap water 1-5 at 110° F., cleanse the wound, using gauze swabs: remove all loose sloughs and totally destroyed soft tissue with the aid of scalpel, scissors, and dissecting forceps. The area should be oozing blood at the end of this stage, which occupies ten to fifteen minutes and requires five to eight pints for a limb.

6. Apply a sterilized envelope sufficiently large to allow free movement of the limb.

7. Continue to use the same solution, irrigating through the inlet by means of a piece of glass tubing 7-8 in. long angled at 45° in its distal 2 in. attached to the rubber tubing leading from a large container, using five pints for a limb. The solution is allowed to escape from the outlet as fast as it runs in so as to get the maximum chemical and mechanical effect.

8. Allow the envelope to drain for 5-10 minutes.

9. Dry the interior of the envelope by means of air blown through a sterile cotton-wool filter, using an electric hair-drier or an electric suction machine applied in the reverse manner. This process takes 10-15 minutes, for it must be thorough.

10. Apply adhesive seals to the outlets and inlets.

**Subsequent Irrigations.**—These are carried out, without anaesthesia, three or four times a day in the ward or in a side room set apart for the purpose. A concentration of 1 per cent electrolytic sodium hypochlorite in tap water 1-20 is used, five pints to a limb, 100° F., from a large container through sterile rubber and glass tubing: the fluid runs out through the rubber tubing attached to an outlet into a receptacle, the limb being placed so that the outflow is as free as possible. The envelope is drained and dried as before and every few days a smear for culture is taken of the wound surface prior to commencing an irrigation. As healing progresses and discharge between the irrigations diminishes, the number of irrigations can be reduced to two a day and the concentration of the solution to 1-100.

#### **Important Points in After-care.**—

1. *Pain.*—The irrigation is usually painless, but a few patients do complain of a smarting sensation which may be severe and this can be overcome by reducing the concentration as low as 1-100 and after a few irrigations increasing by stages until the 1-20 is reached again, when it will be found that this is now tolerated.

2. *Tingling.*—This occasionally occurs, but is not unduly distressing and disappears when the irrigation has ceased.

3. *Temperature of the Irrigation Fluid.*—This should be as constant as possible (100° F.), for in the early stages of treatment patients are apt to be very sensitive to variations in temperature.

4. *Dermatitis: Furunculosis.*—These may be noticed in the area of undamaged skin enclosed in the envelope after two or three weeks' treatment for reasons not understood, but possibly due to inefficient drying. These complications need not interfere with the treatment and soon clear up when the envelope is removed.

5. *Control of Infection.*—The smear taken just before the application of the envelope indicates the organisms present in the wound. Organisms usually found on the skin will continue to be found throughout treatment. Others such as hæmolytic streptococci and *Staph. aureus* will disappear. In a few cases the aid of sulphanilamide powder insufflated through an inlet on to the wound after the drying process is over has to be employed. Occasionally the *Staph. aureus* still persists, but its presence has not delayed healing. Bacteriological examinations can be made at will by taking smears through an inlet immediately prior to an irrigation.

6. *Exuberant Granulations.*—These can be very easily controlled by a pressure dressing of wool and crêpe bandage applied outside the envelope between the irrigations.

7. *Œdema and Splints.*—When there is œdema of the hand and fingers at the time of application of the envelope it is important that this be reduced as quickly as possible, for otherwise function may be permanently impaired. Splints, either in the form of plaster or metal cock-up, are applied outside the envelope: the limb is then elevated with flexion of the elbow by placing it in a sling and suspending it by a pulley and weight from a Balkan beam. The splint is removed for irrigation purposes and whilst this is proceeding active movements are encouraged.

8. *Restoration of Function.*—The size of the envelopes allows of active movements which are encouraged from the beginning, preferably under the guidance of a physiotherapist. A hand in an envelope is soon regularly used at meal times and for writing.

9. *Delayed Healing.*—Healing usually progresses steadily in the envelope, but in a few patients the final stages may be delayed. This is sometimes overcome by reducing the concentration to 1-100: in other cases final healing has occurred only after removal of the envelope and a change to sulphanilamide, tulle gras, and saline gauze dressings.

10. *Opacity of the Envelope.*—Where there is much exudation between irrigations the clarity of the envelope soon diminishes. The addition of ammonium lauryl sulphate (60 min. to 5 pints) to the irrigating solution helps to preserve the clarity.

11. *Life of the Envelope.*—As judged by the appearance of minute holes, especially near the seam, the life is between three and five weeks. The more active the patient, the shorter the life



of the envelope. An anæsthetic is not required for the renewal of the envelope unless it is desired to assist the separation of adherent sloughs by a further irrigation with the more concentrated solution.

12. *Condition of Skin upon Removal of the Envelope.*—In some cases, especially deep second-degree burns, the regenerated epithelium is rather fragile, tending to form blebs if subjected to friction, e.g., when using a billiard cue. These cases, together with all those where skin has been grafted, improve with a course of massage with lanolin (in the more extensive lesions preceded by wax baths) for 10–14 days, a measure which can, with advantage, be continued at home by the patient himself.

**Skin-grafting during Treatment in an Envelope.**—Save in the smaller areas, where there is full-thickness skin loss, time is saved and healing rendered more stable by applying Thiersch grafts. This can only be carried out with any certainty when the hæmolytic streptococcus has been eliminated, as determined by three successive negative reports on smears taken from within the envelope. Exuberant granulations can be flattened by applying a pressure dressing outside the envelope, as already mentioned, between irrigations for the 48 hours immediately preceding the grafting. The amount of discharge between irrigations is a useful guide to the most suitable type of graft. If this is minimal, sheets of graft can be applied with good chance of complete 'take'. Free discharge from granulations, on the other hand, lifts off such sheets and small grafts of the 'pinch' or 'chess-board' variety, which would allow free escape of discharge, have proved more suitable.

#### Grafting Technique Employed.—

1. The donor area on leg, arm, or abdominal wall is prepared in the usual manner.

2. Under an anæsthetic this area is carefully towelled off, the graft cut, and a dressing applied immediately to the raw surface.

3. The envelope is now removed and the unhealed area towelled off and washed in normal saline.

4. Either: (a) Sheet grafts are applied, anchored with marginal sutures, and covered with a layer of tulle gras; or (b) Chess-board grafts are cut in the manner described by Gabarro (1943).

The sheet of graft is spread out, raw surface upwards, on a layer of the paper found between the pieces of tulle gras in the tins supplied by the manufacturers. It is then cut into strips  $\frac{3}{4}$  in. broad with quick cutting movements of sharp scissors. These strips with their adherent paper are then laid upon another piece of the same type of paper in rows  $\frac{3}{4}$  in. apart: this second piece of paper is cut into strips  $\frac{3}{4}$  in. wide in the opposite direction, so that the resulting pieces of graft

are now  $\frac{3}{4}$  in. square. These strips are then applied to sheets of tulle gras so that the squares of graft form a regular chess-board pattern and in this form they are applied to the wound.

5. An envelope is immediately applied and outside this on the grafted area a pressure dressing of wet gauze, wool, and crêpe bandage.

6. *After-treatment.*—The pressure dressing is removed on the third day: the envelope is gently lifted off the tulle gras, and an irrigation (1–20) carried out, taking care to avoid directing the stream on to the grafts. Thereafter irrigations are carried out twice daily and the external dressings dispensed with on the seventh day. The pieces of paper and tulle gras are washed away in a few days by the irrigations, and are removed through an outlet.

## ILLUSTRATIVE CASES

### RECENT BURNS

Five cases, all of second degree, have been treated by the immediate application of envelopes:

CASE	AREAS BURNT	FIRST-AID TREATMENT	AGE OF BURN	DAYS IN ENVELOPE	DAYS IN HOSPITAL
A	R. lower leg under elastic stocking covering healed varicose ulcer	Salad oil	3 hr.	27	30
B	Dorsum both hands, wrists, and finger	Tannic acid jelly. Saline compresses	4 hr.	left, 10 right, 36	40
C	Face. Anterior and posterior aspect hands	Saline compresses	4 hr.	13	34
D	Face. Dorsum left hand	Nil	4 hr.	9	18
E	Dorsum both feet	Saline compresses	6 hr.	9	12

in all *Staph. aureus* was grown from smears taken at the initial cleansing. All healed soundly without cross-infection (a large furuncle appeared on the right wrist of Case C from which *Staph. aureus* was grown, and this delayed final healing). Full movements were maintained throughout, all the hand cases using knives and forks at their meals.

### OLD BURNS

(i.e. 48 hours or more)

Eleven cases have been treated, the time between receipt of injury and admission to this hospital varying from three days to two years. Of these 3 were naval ratings (Cases 1, 2, and 3) admitted 72 hours after partaking in the raid on Dieppe. They were all members of the same gun crew and were burnt when an enemy shell exploded close to them. Within half an hour gentian violet solution had been applied, with one further application on reaching land, and cotton bandages applied. It is interesting to observe that Case 3 stated he felt his fingers slowly "contracting", owing, he thought, to the drying of the solution.



**Case 1 (183).**—Admitted on Aug. 23, 1942, with second-degree burns of whole of foot, ankle, and heel, areas of third-degree burns on dorsum, all infected.

**TREATMENT.**—Application of envelope and irrigations; these caused pain and the strength had to be reduced to 1–100, but at the end of the week a 1–20 solution was tolerated without pain. Active movements were encouraged from the beginning; 80° flexion of ankle was possible on the 16th day. Envelope removed after 26 days with healing completed except in two areas which rapidly responded to 5 per cent sulphanilamide ointment. The new epithelium was purplish in colour, tending to break down in one or two areas when wearing shoes. Kept off weight-bearing until the 58th day, using crutches in the meantime and being given massage and wax baths.

**Discharged** Nov. 12 (81st day) with 100 per cent function and sound epithelial covering.

**BACTERIOLOGY.**—Hæmolytic streptococcus on the application of envelope.

**Case 2 (177).**—Admitted Aug. 23, 1942, with second-degree burns involving almost the whole of the face, both arms from shoulders to fingers, including the axilla and scapula area on the left side. Several scattered areas of third-degree burns on the arms. Multiple blisters and large areas of raised coagulum.

**TREATMENT.**—Taken to the theatre on day of admission and all areas cleansed with normal saline, dried sulphanilamide powder applied and 1 per cent gentian violet solution applied to the upper arms, tulle gras and saline compresses to the face and hands. For the next three days saline baths for the hands twice a day; encouraged by the physiotherapist to move all joints. He was extremely uncomfortable, perspired freely, and it was a matter of great difficulty to keep the arms dry. Mr. Kilner then saw him and advised the application of an envelope in the form of a smock. This was applied on the third day and there followed a dramatic improvement in his general condition and outlook. He was comfortable, tolerating four-hourly irrigations very well and co-operating with a full range of active movement (supervised twice a day by a physiotherapist). Between irrigations his limbs were elevated in slings suspended from Balkan beams.

The smock was changed once: he was using both hands at meal times on the 16th day, i.e., 13 days after the application of the smock. On the 26th day the smock was removed except for the left sleeve, as the right side had healed except for one or two tiny areas: the left side was healed in 62 days, save again for similar small areas. Healing was complete throughout on the 69th day, but as in Case 1, the new epithelium was purplish and shiny, and blebs formed from time to time. Massage with lanolin was given on removal of the smock, which soon improved the condition of the epithelium.

**Discharged** 93 days after admission with 100 per cent function of all joints and sound healing. A letter was received from this Naval rating six months later expressing gratitude and stating that his limbs were in sound condition.

**BACTERIOLOGY.**—Smears taken on application of the envelope and at subsequent dates showed *Ps. pyocyaneus*, *Staph. aureus* and *albus*, diphtheroid bacilli, *B. proteus vulgaris*, and *Str. fecalis*, but at no time was a hæmolytic streptococcus discovered.

**Case 3 (182).**—Admitted Aug. 23, 1942, with second-degree burns involving whole of both wrists, hands, and fingers; several small areas of third-degree

burns. Second-degree burns of whole of face. Most of the coagulum was raised with pus beneath.

**TREATMENT.**—Cleansed in the theatre, dried, sulphanilamide powder, tulle gras, and saline compresses applied. Thereafter he had arm baths in normal saline twice a day, the dressings being allowed to float off and fresh ones re-applied after the bathing. He was in poor condition and loathed his baths, as they left him 'exhausted': he was disinclined to co-operate with active movements. On the 5th day he was given an anæsthetic and envelopes were applied to both forearms and hands. Outside these, cock-up splints were applied and the limbs elevated in slings suspended from Balkan beams with the elbows in 90° flexion. Irrigations were carried out four-hourly, the splints being removed, and active movements were encouraged by the physiotherapist. Eleven days after the application of the envelopes he was using both hands at meal times, so that elevation and splinting were discarded altogether during the day time. Six days later healing was complete except for small areas over the knuckles, which reacted well to sulphanilamide ointment. Massage with lanolin followed, but again the epithelium showed a tendency to bleb formation after friction, such as using a billiard cue or a broom. Such exercise was suspended for a few days until his epithelium appeared in better condition.

**Discharged** 53 days after admission with 100 per cent function and sound epithelium.

**Comment.**—These 3 cases were the first in which envelope therapy was tried; the striking improvement in the general condition of all three and the uninterrupted progress of healing with maintenance of function from the beginning, revealed convincing evidence of the value of the early application of this treatment.

**Case 4 (301).**—Admitted Nov. 2, 1942. A member of the R.A.F. who eight days previously received extensive scalds on the dorsum of the right foot. Various applications had been used, including gentian violet, liquid paraffin, saline, and acriflavine, the foot being covered with bandages after every treatment. On admission the area was infected, with raising of the coagulum and slough formation.

**TREATMENT.**—An envelope was applied on the day of admission, changed in three weeks, this being renewed after another three weeks with healing complete save for one small area the size of a sixpenny piece. Wax baths and massage with lanolin followed and active movements had been supervised from the beginning.

**Discharged** 69 days after admission with full function and sound epithelium.

**BACTERIOLOGY.**—On admission hæmolytic streptococcus, *Staph. aureus*, diphtheroid bacilli.

Nov. 18: No change.

Dec. 10: *Staph. aureus* and *albus*.

Dec. 16: *Staph. aureus* and diphtheroid bacilli.

**Comment.**—Hæmolytic streptococcus disappeared during treatment in the envelope. Duration of hospitalization would have been considerably reduced had the envelope been applied immediately after the accident.

**Case 5 (422).**—Admitted March 11, 1942. A member of the W.A.A.F. who scalded her left lower leg just above the ankle on Jan. 1 whilst on leave. Her own doctor applied gentian violet. On returning to her unit she attended the sick bay three times a day

for dressings and various applications were tried. For seven weeks prior to admission to this hospital she had been in bed in the sick bay having sulphanilamide powder and saline compresses applied to the area three times a day. Apparently from time to time new epithelium was seen growing in from the edges, but this soon disappeared. A few days before admission a generalized rash appeared and persisted. On admission there was an irregular granulating area 4 in. in diameter, with an uneven base, quite clean. There was a generalized hard papular rash with several pustules.

**TREATMENT.**—Envelope applied without an anæsthetic and in seven days the ulcer had been reduced in size to 1 in.  $\times$   $\frac{1}{2}$  in. Envelope removed on the 16th day, massage with lanolin following.

**Discharged** on the 42nd day after admission with 100 per cent function.

**BACTERIOLOGY.**—Debris only. Culture sterile.

**Comment.**—An example of over-zealous use of sulphanilamide powder as a local application, and of too frequent dressings.

**Case 6 (237).**—Admitted Oct. 12, 1942. A child aged 6 years, who received third-degree burns of the right lower leg in May, 1942. She was admitted to the local hospital and three or four weeks later she had fever, cyanosis, pallor, hæmaturia, and was mentally deranged. These symptoms were attributed to poisoning by sulphanilamide, which had been given for two weeks in the form of twice-daily applications of 5 per cent sulphanilamide ointment, 36 hours of generous application of pure sulphanilamide powder, and 24 hours of 0.5 g. by mouth four-hourly. This drug was stopped at once and eusol used as a local application. On admission her general condition was poor, she was frightened at the thought of having the dressings changed, and presented a granulating area involving the whole circumference of the middle-third of her right lower leg. Hæmolytic streptococci were found in her throat and also in the granulating area, together with *Staph. aureus* and *albus*.

**TREATMENT.**—An envelope was applied and immediately her fear of dressings disappeared, for the irrigations were painless. Her general condition improved, appetite was regained, and she co-operated well with her active movements. The envelope was changed in a month, by which time the hæmolytic streptococcus had disappeared, the other organisms persisting. Healing had progressed very well, but after three weeks in the new envelope little further progress was made although the streptococcus had not reappeared. The envelope was removed on the 43rd day and the unhealed area, measuring  $1\frac{1}{2}$  in.  $\times$   $\frac{1}{2}$  in., was dressed with cod-liver oil. Progress was very slow, and on the 59th day there was a breakdown of the surrounding epithelium, increasing the size of the ulcer to 2 in.  $\times$   $1\frac{1}{2}$  in., and the streptococcus was grown from the area and from the throat. The wound was dressed with a very small amount of sulphanilamide powder, tulle gras, and saline; this was followed by the disappearance of the streptococcus, so that on the 71st day a Thiersch graft was applied. This failed, coinciding with the reappearance of the streptococcus. Pinch grafts were tried three weeks later, but these failed, the streptococcus persisting in the leg and throat. Tonsillectomy was performed on Feb. 1, 1943, and the leg dressed with saturated sodium sulphate. Four months after admission there was an ulcer 1 in. in diameter anteriorly and four smaller ulcers posteriorly from which the streptococcus was grown. Propamidine was applied on

alternate days for 10 days, resulting in the healing of the anterior ulcer and three of the posterior ulcers. A scanty growth of streptococci was obtained from the remaining ulcer. A week later this ulcer had increased in size and a second course of propamidine was given, resulting in a reduction in size, but the organism still persisted. On April 19, i.e., six months after admission, there was an increase in the amount of discharge from the posterior ulcer and there was a small ulcer anteriorly. Propamidine dressings were then applied at intervals of two or three days for a month, by which time both ulcers had healed and during which a negative report was received.

**Discharged** 10 months after admission with full function and completely healed. Follow-up examinations have been made three and again six months after the date of discharge. The leg is of good shape and the area remains soundly healed.

**Comment.**—A patient hypersensitive to sulphonamides who carried hæmolytic streptococci in her throat despite tonsillectomy. These organisms had disappeared whilst the leg was in the envelope, only to reappear when this was removed. Propamidine in the dosage recommended failed to bring about complete healing or the disappearance of the organism, but a third trial extending well beyond the ten days brought about a cure.

## WOUNDS WITH SKIN LOSS

**Case 7 (232).**—Admitted Oct. 13, 1942. A girl, aged 17, whose dress caught fire on Nov. 21, 1940, as the result of which she received burns of both thighs, both lower legs, the back, right upper arm and elbow, left hand and elbow.

She was admitted to her local hospital the same day and remained there as an in-patient for six months. During this time various forms of local therapy were tried, including (a) acriflavine dressings, (b) tannic acid, (c) liquid paraffin, (d) eusol, (e) eucalyptus ointment, (f) cod-liver oil, (g) small Thiersch graft from lower leg to thigh. Throughout her stay in the hospital she lay flat on her back with a pillow under her knees.

At the end of six months her mother took her home against medical advice: her own doctor paid frequent visits, repeatedly applying tannic-acid spray to the large unhealed areas on the thighs and legs. After seventeen months of this treatment at home she was sent as an in-patient to a hospital in London where she was given a transfusion of whole blood and transferred to Stoke Mandeville Hospital fourteen days later. On admission there was marked pallor of skin, she was thin and under-developed for her age, and was extremely apprehensive at the thought of having the dressings changed. Local findings: (1) Whole of the anterior surface and half the circumference of the right thigh and the upper two-thirds of the anterior aspect and half the circumference of the left thigh were covered with pink protuberant granulations; extreme wasting of the thigh muscles. (2) 45° flexion contracture of both hips and 90° flexion contracture of both knees. (3) Granulating areas about 2½ in. in diameter on the buttocks and middle of the posterior aspect of the lower legs. Pathological findings: Hæmoglobin 65 per cent; colour index 0.7; Group AB. A growth of *Staph. aureus* and diphtheroid bacilli from all areas.

**TREATMENT.**—Full-leg Stannard envelopes applied under anæsthesia the day after admission, preceded by cleansing of the areas in the routine manner.

Active movements of the hips and knees were encouraged, under the supervision of the physiotherapist, from the beginning. Owing to her apprehension the weakest solutions were used for the first four days, by the end of which she had completely regained her confidence, was cheerful, taking an interest in her ward companions, and co-operating with the physiotherapist. Eight days later Thiersch grafts were taken from the anterior abdominal wall and from the anterior chest wall. The Stannard envelopes were removed and the granulating areas on the thighs, now much cleaner and flatter than on admission, were washed with 1-5 Milton. The sheets of graft were applied so as to form a spiral covering anchored with a few marginal sutures and several smaller grafts were used in the postage-stamp manner, and the whole area then covered with tulle gras. New Stannard envelopes were applied and pressure dressings outside these over the grafted areas. The bacteriological findings at this stage were *Staph. aureus*, *Proteus vulgaris*, and diphtheroid bacilli. The first irrigation was carried out four days later and thereafter once daily for a week, after which the pressure dressings were discarded and irrigations carried out twice daily. All the grafts took, and from then onwards healing steadily progressed. Five weeks later the envelopes were removed; two-thirds of the granulating areas were covered with epithelium, and pinch grafts (50), taken from the anterior abdominal wall, were applied to the remaining unhealed areas. The lower legs and buttocks were soundly healed. Four of the pinch grafts failed to take. Eleven weeks after admission she began to walk without the support of the physiotherapist. At the end of the 14th week all the areas were healed and the muscles had developed well, but there remained 20° flexion contracture of the left knee and 30° of the right. Extension by means of spats made of bandage and Unna's paste was applied for three weeks, which resulted in full correction of the left knee and of the right except for 5°. Walking exercises were resumed, together with the rehabilitation measures: the skin of the thighs broke down in one or two small areas at intervals, but six months after admission all areas were soundly healed, her posture and her lordosis had been corrected, her progress was excellent, and she walked well and was discharged. She was reviewed as an out-patient six months later. All the areas had remained healed—she had gained weight—could walk two miles with ease and without any sign of œdema of the ankles.

**Comment.**—Two and a half years elapsed between the date of the accident and full recovery. With treatment in Stannard envelopes and early grafting the greater part of this time would have been avoided. An example of grafting with immediate continuation of envelope therapy.

**Case 8 (412).**—Admitted March 9, 1943. A child, aged 6, who six days before was in a house bombed during an air raid, receiving third-degree and fourth-degree burns of the posterior aspect of the right elbow and upper two-thirds of the forearm, with 2 in. of the upper end of the shaft of the ulna exposed; third-degree burns of the upper half of anterior aspect of the right thigh and small scattered areas of third-degree burns of the perineum, groin, right ear, and left index finger. He had been given a transfusion of plasma and the burns cleansed, followed by the application of saline compresses. On the third day an envelope had been applied to the forearm, but was removed the next day.

On admission he was in poor general condition, pale, tired, fretful, and apprehensive lest his dressings were to be changed. All the burnt areas were covered with thick slough.

**TREATMENT.**—An envelope was applied after removal of the slough under a stream of hypochlorite solution. Irrigations of the 1-20 solution were painful, so that the strength was reduced to 1-100 for six days. His general condition improved at once and he was soon eating well and taking a lively interest in his surroundings and fellow patients. The discharge between irrigations was profuse for the first fortnight: on the 9th day a slough separated from the posterior external aspect of the elbow-joint, revealing a defect in the capsule and synovial membrane. An anterior splint of plaster was made to keep the elbow at 90° flexion between irrigations. At the application of the envelope there was a heavy growth of hæmolytic streptococci and *Proteus vulgaris*, but the former disappeared two weeks later, with the use of insufflations of sulphanilamide. On the 17th day chess-board type Thiersch grafts were applied to forearm and thigh, with immediate application of envelopes. The first irrigation was carried out three days later and thereafter twice daily, using the 1-20 solution. Four of the grafts were much too thinly cut and failed to take, otherwise healing steadily progressed. Seven weeks after admission the arm had healed completely except for the projecting upper end of the ulnar shaft—there was no sign of a communication with the joint cavity and there was a full range of movement. In the thigh 80 per cent of the area had healed and the envelope was changed. In the 9th week this was removed, leaving an area the size of sixpence unhealed. A week later the projecting portion of ulnar shaft was removed as a sequestrum, and was followed by the application of another envelope.

**Comment.**—An example of the disappearance of the hæmolytic streptococcus during envelope therapy, grafting, and continuing in the envelope, followed by rapid healing. At the time of writing the case is still under treatment: the child has 100 per cent function in all joints, running about the ward, and will be discharged as soon as the upper end of the ulna is covered with sound skin.

**Case 9 (145).**—Admitted Sept. 4, 1942. A child, aged 10, who two months previously, whilst walking with one foot in the gutter and the other on the pavement, was hit from behind by a motor lorry. He was admitted to the local hospital with a large area of skin loss of the left lower leg. A long leg plaster was applied and removed ten days later, after which he had dressings every other day.

On admission there was an unhealthy granulating area from just below the knee-joint to the malleolus, involving the whole circumference of the leg. There were scattered granulating areas around the right knee and lower leg.

**TREATMENT.**—Envelopes were applied to both legs, from which were grown *Ps. pyocyaneus*, *Staph. aureus*, and diphtheroid bacilli. On the 19th day the envelopes were changed, the same organisms being found. There was 20° limitation of full extension during active movements of the left knee, and a padded splint of Kramer wire was applied behind the joint in full extension outside the envelope. On the 35th day a sheet of Thiersch graft 5 in. × 3 in. was applied to the left lower leg, covering roughly 50 per cent of the unhealed area—a sheet rather than the chess-board

pattern because the amount of discharge between irrigations was small. An envelope was immediately applied, the first irrigation being carried out three days later and subsequently twice a day with the 1-20 solution. There was a 100 per cent take of this graft, and ten days after applying the graft the splint was discarded during the day, when active movements against resistance were encouraged. On the 63rd day a smear revealed *Staph. aureus* and diphtheroid bacilli; the next day a sheet of Thiersch graft was applied to the remaining unhealed area, followed by the immediate application of an envelope. Thereafter treatment was as before, but this time there was a small area of failure of take measuring 1 in.  $\times$   $\frac{1}{2}$  in. The envelope was removed 18 days after applying the graft, followed by cod-liver oil dressings. Re-education in walking was commenced, a slow process because of troublesome oedema of ankle and foot after weight-bearing.

In the 17th week after admission he was walking without limp or oedema, with a sound covering of skin throughout; but as the ward was in quarantine because of chicken-pox, discharge was delayed for a further six weeks.

**Comment.**—An example of successful sheet Thiersch-grafting during envelope therapy in the presence of discharge containing *Ps. pyocyaneus* and *Staph. aureus*. The grafting could have been carried out earlier had envelope therapy been instituted at the beginning.

### INDOLENT ULCER WOUNDS

**Case 10 (383).**—Admitted Feb. 2, 1943. A female, aged 31 years, who had injections for varicose veins in her right leg in March, 1938, followed by septicaemia, suppurative arthritis, and eventually ankylosis of the right hip, ankle, and tarsal joints, and a limited range of movement of the knee. An ulcer 1 in. in diameter immediately below and behind the internal malleolus had remained unhealed for four years.

On admission this ulcer was covered with a firm scab which apparently formed from time to time and then separated, leaving the ulcer as before.

**TREATMENT.**—An envelope was applied and three weeks later healing was complete. The envelope was removed and a Viscopaste bandage applied to the lower leg: the patient was allowed up from this time.

**Discharged** 5 weeks after admission—ulcer healed, complete return of function possible prior to admission.

**PROGRESS.**—She was seen six months later when the skin over the ulcer area was still sound and had not given any trouble since the date of her discharge.

**Case 11 (374).**—Admitted Jan. 15, 1943. A sailor, who on Oct. 8, 1942, caught his left heel between the moving platform of a gun and the deck of the ship, sustaining a lacerated wound from just below the internal malleolus, running downwards and forwards almost to the outer side of the sole. This extended down to the os calcis; there was no fracture and the wound after excision of the edges was sutured, followed by the application of a lower-leg plaster. This plaster was removed three weeks later, but healing was incomplete. He could not walk because of pain, and local dressings were applied. On admission there was an unhealed area below and behind the internal malleolus  $1\frac{1}{2}$  in.  $\times$   $\frac{1}{2}$  in., pear-shaped, a clean granulating base shallow above and deep below.

**TREATMENT.**—An envelope was applied, the smear revealing *Staph. aureus* only. Healing was complete in six weeks; he had been using crutches throughout,

and in the 7th week re-education in walking was begun.

**Discharged** 11 weeks after admission with 100 per cent function and fit for duty.

**Comment.**—This case had defied all efforts with local applications and was referred to this Unit with the suggestion that a skin-graft was the only solution.

**Case 12 (350).**—Admitted Nov. 19, 1942.—A sailor who received a shrapnel wound resulting in a compound fracture of the right fourth metatarsal. The edges of the wound were excised, fragments of shrapnel removed, and a lower-leg plaster applied. On admission there was an unhealed wound  $1\frac{1}{2}$  in.  $\times$  2 in. over the dorsum of the fourth metatarsal.

**TREATMENT.**—An envelope was applied: the smear revealed haemolytic streptococci. Healing was complete in the 9th week. Thereafter he was given saline soaks, wax baths, and massage with lanolin, followed by re-education in walking.

**Discharged** 11 weeks after admission with 100 per cent function and fit for duty.

**Comment.**—Delayed healing due no doubt to unrecognized presence of haemolytic streptococcus. He was transferred to this Unit with the suggestion that he was a suitable case for the application of a direct flap from the other leg.

### CONCLUSIONS

Envelope therapy provides a reliable yet simple method of treating burns and wounds with full-thickness skin loss.

In the majority of our cases we were asked to undertake treatment some time after the original injury: our experience leads us to believe that if this therapy had been instituted at once much time and pain would have been saved, and damage caused by infection prevented. It would appear to be an ideal method of eliminating the haemolytic streptococcus, and reducing risk of cross-infection to a minimum.

Two further striking features have been the dramatic improvement of general condition and the maintenance of full function in every case.

The method compares favourably with others in common use: the pain and repeated disturbance of newly-regenerated epithelium with constant risk of infection and cross-infection, the bugbear of other methods, are entirely avoided.

### SUMMARY

1. The objects of treatment of burns and wounds with skin loss of varying degree are outlined, and it is shown how envelope therapy fulfils these.

2. The technique of sterilizing Stannard envelopes is described.

3. The method of using the envelopes is described in detail.

4. Methods of combining skin-grafting with envelope therapy are explained.

5. Several case histories are given, showing the value of the method in recent and old burns and wounds with skin loss.

I am deeply indebted to Professor T. Pomfret Kilner for constant encouragement and advice whilst investigating this method and in the preparation of the paper; to Mr. Stannard for providing a generous quantity of the new tie-on envelopes; to my colleagues and members of the nursing staff at Stoke Mandeville Hospital for their co-operation and enthusiasm; and, finally, to Dr. F. Hall, Medical Officer of Health

for Lancashire, for making it possible for me to be seconded to this hospital for training.

#### REFERENCES

- BUNYAN, J. (1941), *Brit. med. J.*, 2, 1.  
 Editorial (1941), *Ibid.*, 2, 53.  
 GABARRO, P. (1943), *Ibid.*, 1, 723.  
 HANNAY, J. W. (1941), *Ibid.*, 2, 46.  
 HUDSON, R. V. (1941), *Ibid.*, 2, 7.  
 PEARSON, R. S. B., et al. (1941), *Ibid.*, 2, 41.

## THE DIAGNOSIS OF THE DEPTH OF SKIN DESTRUCTION IN BURNS AND ITS BEARING ON TREATMENT\*

By DAVID H. PATEY AND R. W. SCARFF

FROM THE WARDS AND FROM THE BLAND-SUTTON INSTITUTE OF PATHOLOGY,  
 THE MIDDLESEX HOSPITAL

DURING the air raids of 1940-41, when a number of cases of burns were admitted to the Middlesex Hospital, we were impressed by the difficulty which even experienced observers found in assessing accurately the depth of skin destruction during the acute phase. The prognosis of burns depends very largely on the depth of skin destruction; the principles of treatment of a superficial

Further to correlate clinical and histological appearances the investigation was extended to burns produced experimentally under standard conditions in the skin of breasts immediately before removal for carcinoma. Our results may therefore conveniently be considered under the two headings: (1) Clinical material; (2) Experimental material.



FIG. 18.—Blister with intra-epithelial separation. Hæmatoxylin and eosin. ( $\times 20$ .)



FIG. 19.—Complete separation of surface epithelium. Hæmatoxylin and eosin. ( $\times 45$ )

burn may be quite different from those of a deeper burn, and it is unfair to compare the results of different types of treatment unless it can be proved that the cases were strictly comparable. We therefore decided to see whether histological methods were a practical means of obtaining more accurate information about the depth of skin destruction in burns. Our first investigations were of patients admitted to the hospital with accidental burns, from whom portions of burnt skin were removed and microscopied.

\* A preliminary report (unpublished) was read at the meeting of The Association of Surgeons in July, 1943.

#### CLINICAL MATERIAL

##### HISTOLOGICAL EXAMINATION

The most obvious material for histological investigation in patients with burns is the skin separated by blistering. This shed blistered skin is found to be well fixed by the heat of the burn and makes reasonably good histological material. We find that there are two planes of separation in blistering—through the stratum granulosum (Fig. 18) and deep to the stratum malpighii (Fig. 19), in the latter all the surface epithelium being lost but leaving hair follicles and glandular structures in the dermis. In neither our clinical nor experimental material have we found anything to support the conception of a plane of

separation deep in the epithelium leaving behind the interpapillary epithelial processes (rete pegs) on which so much stress used to be laid in the older classifications. Blistering appears to be an active protective mechanism, and a rapid means

by blistering is separated at a given plane gives no information as to the state of the dermis deep to the blister and usually the diagnosis that there has been coagulation necrosis of the dermis in addition to the blistering is not made on the immediate

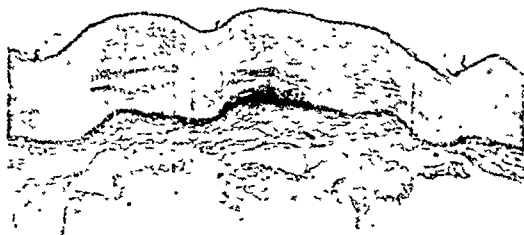


FIG. 20.—From palm of hand. Apparently deep separation, but material consists of keratin and superficial epithelium only. Hæmatoxylin and eosin. ( $\times 45$ .)

for throwing off damaged or killed epithelium. There is no similar rapid vital mechanism for throwing off necrosed dermis, which is separated by the slower mechanism of the formation of a granulation tissue barrier. But at high temperatures, blistering may be simulated by the purely physical process of maceration, in which layers of the dermis may flake off.

A burn covering a large area constitutes a mosaic work of varying depths of destruction. Clinically, the assessment of the depth of epithelial destruction tends to be influenced by the thickness of the shed blistered skin. But this is misleading, as in situations in which the epithelium is thick, e.g., the palm of the hand, there may be a thick blister even though the plane of separation is through the stratum granulosum, whereas in situations in which the skin is thin, e.g., over the back of the hand or over the breast, a thin and apparently insignificant blister may contain the whole of the surface epithelium. By microscoping representative samples of blistered skin from different areas, a truer picture of the pattern of epithelial destruction may be built up. We have had two striking cases in which a first clinical diagnosis of deep epithelial destruction in the palm of the hand and superficial epithelial destruction in the forearm has been proved by histology to be just the reverse (Figs. 20, 21). The subsequent clinical course confirmed the histological findings.

In severe cases of burns it is often easy to recognize with the naked eye that there has been whole-thickness skin destruction from its dead yellowish-white or brown appearance. In many of these cases of obvious whole-thickness skin destruction there is no blistering, the necrosed epithelium remaining fused with the necrosed dermis. But the demonstration that the epithelium shed



FIG. 21.—From forearm of same case as Fig. 20. The apparently thin membrane contains all the surface epithelium. ( $\times 45$ .)

appearances but on the progress of the case. It is to this question of the immediate diagnosis of dermal destruction not obvious to the naked eye that we have particularly directed our attention.

Coagulation necrosis of the dermis can be recognized histologically. With hæmatoxylin and eosin, it stains slightly more deeply than the normal dermis and presents a condensed and

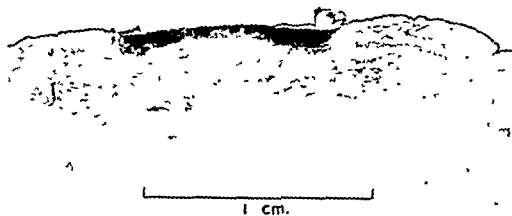


FIG. 22.—Experimental burn stained by Werlhof's method. ( $\times 275$ .)

hyaline appearance. We also found that coagulation necrosis of the dermis stains differentially black with Werlhof's elastic stain (Fig. 22). Leach, Peters, and Rossiter (1943) have also noted that collagen fibrils damaged by burning show an increased affinity for basic dyes whilst their affinity for acid dyes is decreased.

#### FACTORS IN HEALING

With surface epithelial destruction only, even if complete, rapid primary epithelialization in

situ should in theory be the rule if the hair follicles and glands in the dermis are not damaged either by the original burn or subsequently. As we have already stated, there is no evidence for regeneration from the interpapillary processes of the skin (rete pegs), and from our observations it seems almost certain that the areas of regeneration formerly attributed to this cause are in reality derived from the ducts of follicles or

object of treatment should be to replace the skin destroyed by grafted skin as soon as possible. In many cases, the diagnosis of complete skin destruction is easy clinically, and a primary débridement and skin-grafting is possible. In the majority of cases, however, a diagnosis of the degree of dermal destruction is not possible in the acute stage, so that the standard treatment is expectant, with secondary grafting during the granulating phase. If sample pieces of dermis are cut out and examined microscopically, the degree of dermal necrosis can be seen. But this method has obvious disadvantages in practical application.

#### APPLICATION AND LIMITATIONS OF METHOD

On a histological basis, burns of the skin can be classified in two groups: (1) Burns with surface epithelial destruction only; (2) Burns with surface epithelial destruction plus varying degrees of dermal destruction. The first group can again be subdivided into: (a) Superficial blistering; (b) Deep blistering.

The classification of burns into 1st, 2nd, and 3rd degree and so on, is undesirable owing to the variety of classifications and consequent confusion. For clearness, in describing a burn, the depth of tissue destruction should be stated in words.

In many cases it is obvious that there is coagulation of the dermis, but in most it is impossible to be certain on the point clinically, and it is in these instances that histological control is especially valuable. Great assistance is given if examination of the material shows that the separation is intra-epithelial in character, as in these cases dermal damage is improbable; the material is less valuable if, as is frequently the case, there is complete shedding of the surface epithelium, as there is usually no indication of the presence or amount of underlying dermal damage. Another objection to the method too, is the time that must elapse before the section is produced. It is these limitations that have led us to carry out experimental work to find a rapid method for estimating the degree of dermal involvement.

#### EXPERIMENTAL MATERIAL

In an endeavour to find a rapid method of assessing the depths of burns, we made some experimental burns on the skin of breasts immediately before removal for carcinoma.

**Standardization of Technique.**—After the trial of various methods for producing experimental burns, including diathermy and a glass test-tube, we finally used as a standard a metal test-tube approximately 1 cm. in diameter containing paraffin wax into which was inserted a centigrade thermometer which passed through a double perforated cork. The metal of the test-tube transmitted heat better than glass, and the fear of breaking was absent. The test-tube



FIG. 23.—Section of skin-graft. Shows the line of removal in dermis passing through glands and hair follicles. ( $\times 45$ .)

glands. The importance of these dermal epithelial structures has been emphasized in recent years by a study of the donor area in partial-thickness skin-grafts (e.g., Brown, 1943). Fig. 23 illustrates a section of such graft from one of our cases, from which it can be seen that the whole surface epithelium has been removed. Yet re-epithelialization of the donor area was complete in 14 days. Therefore, in burns with surface epithelial destruction only, the object of treatment should be to combat factors tending to destroy, damage, or interfere with the growth of the epithelial structures in the dermis. The chief damaging factors are three: sepsis, œdema, and trauma, either traumatic dressings or the trauma of unrelieved weight-bearing. We have, like others, found evidence to support the importance of these factors, of which sepsis is the chief, and probably the main advances in the modern treatment of burns derive from chemotherapeutic advances in combating sepsis. Chronic œdema is a recognized inhibiting factor in healing and is now as a routine combated by gravity or by pressure dressings. The importance of the trauma of unrelieved weight-bearing is less generally recognized. It is frequently seen in the delay in the healing of the skin over the calf and over the inner side of the elbow, points on which the weight of the limb in bed particularly bears. It is a special problem in burns involving the whole circumference of the trunk.

Cases with dermal destruction present a different problem. The English school of plastic surgery (e.g., McIndoe, 1940) deserve the main credit for emphasizing that in these cases the



was heated up to the desired level and its base applied for the determined time. The skin used was that of the breast at the beginning of an operation for carcinoma. The number of applications to any one breast varied, but was usually four or five. Note was made of the temperature and time of each application and a comparison subsequently made with the histological appearances. This procedure gave the opportunity for the study of the appearances of the whole thickness of the skin after burning, and not merely of the shed blistered skin as in most of the clinical material.

**Results.**—There is no absolute response of skin to a given temperature for a given time. The effects may vary both with the condition of the skin and the burning agent. For example, when, in the earlier stages of the investigation, we used a larger test-tube than we finally used, the burn effects for a given temperature and time were more marked, owing presumably to the greater cooling effects of the blood-vessels the smaller the area burnt. With our standard technique, we found that at 80° C. for 10 seconds there was complete separation of the epithelium without histologically demonstrable dermal changes; above this temperature increasing degrees of dermal necrosis could be seen.

**Clinical Use of Stains.**—We have already noted that coagulation necrosis of the dermis stains black with Werlhof's elastic stain. This finding led us to explore the possibility of the use of a stain clinically on burnt areas which would pick out the areas of dermal necrosis. The most satisfactory so far has been a modified Van Gieson's stain (picro-fuchsin)—a 0.2 per cent solution of acid fuchsin in a half saturated solution of picric acid in water (approximately 1 per cent). This is normally bright red in colour. If applied to an area without dermal necrosis the area stains red; such an appearance is seen in the donor area of a skin-graft or in a burn with only surface epithelial destruction after the blister has been wiped off. With minor degrees of dermal

necrosis a yellowish tinge appears, and where this necrosis is marked a bright yellow tinge results without any red. The necrosed dermis seems to pick out specifically the yellow of the picric acid. We suggest that by some such method of differentiation as this, a large number of cases of dermal necrosis may be recognized clinically in the acute phase, and treated by primary débridement and skin-grafting.

## SUMMARY

1. An attempt has been made to achieve by histological methods a greater degree of accuracy in estimating the depth of destruction in skin burns.
2. A standard technique for producing experimental burns in human skin is described.
3. Histological examination of the shed blistered skin is of value in the determination of the depth of damage and in the control of treatment of superficial burns.
4. Such examination is especially valuable if it shows the plane of separation to be intra-epithelial; it is of less value if it shows complete epithelial separation, as there is no indication of the presence or extent of the underlying damage.
5. The degree of dermal destruction can be assessed by differential staining of whole-thickness skin sections, but the taking of such sections on a large scale has practical objections.
6. Attempts have been made to find a stain which, applied to the burnt area in the patient, will give some naked-eye indication of the degree of dermal involvement. A modified Van Gieson's stain has been found useful for this purpose.

## REFERENCES

- BROWN, J. B., and McDOWELL, F. (1943), *Skin Grafting of Burns*. Philadelphia and London: J. B. Lippincott Co.
- LEACH, E. H., PETERS, R. A., and ROSSITER, R. J. (1943), *Quart. J. exp. Phys.*, **32**, 67.
- McINDOE, A. H. (1940), *Proc. R. Soc. Med.*, **34**, 56.

## RECENT ADVANCES IN THE TREATMENT OF CARCINOMA OF THE MOUTH AND JAWS

BY T. H. SOMERVELL

NEYYOOR, TRAVANCORE, S. INDIA

IN the coastal districts of South India and Ceylon epithelioma of the mouth, including tongue, jaws, cheek, and lips, is extremely common, and occurs far more frequently than cancer or sarcoma in all other situations put together. Twenty years' experience of treating this variety of carcinoma in a large mission hospital in South India (The London Mission Hospital, Neyyoor, Travancore) has enabled the writer to study, and to practise extensively, various methods of treatment—by operation and by radium and X-ray therapy,

and by these latter combined with operation—and to devise certain improvements in technique which, he feels, should be more widely known.

Out of the 10,480 operations for malignant disease (Table I) performed in this hospital during the years 1923–42 inclusive, 8439 were done for epithelioma of the mouth, including cheek, lips, tongue, and jaws, these operations being performed on 4853 patients. Of these the number of cases of epithelioma in the various situations is shown in Table II.



Table I.—NUMBER OF OPERATIONS FOR MALIGNANT DISEASE IN VARIOUS SITUATIONS PERFORMED AT NEYYOOR HOSPITAL, DURING THE YEARS 1923-1942 INCLUSIVE

Mouth :	
Upper jaw	349
Lower jaw	1338
Cheek	2177
Tongue	623
Diathermy of Cheek	356
Glands	2590
Breast	113
Penis	171
Rectum	48
Cervix	558
Skin	316
Larynx and pharynx	62
Other	277
Abdominal :	
Stomach	87
Ovary	23
Intestine	14
Total operations for carcinoma :	
Primary	9129
Secondary	996
Sarcoma, etc.	355
Total operations for malignant disease	10,480
Total operations for malignant disease of mouth	7445
Total patients with malignant disease of mouth	4853

Table II.—SITE INCIDENCE OF EPITHELIOMA OF MOUTH

Cheek and lips	2533 (52 per cent)
Lower jaw	1338 (28 per cent)
Upper jaw	349 (7 per cent)
Tongue	633 (13 per cent)
Total cases	4853
Separate operations on glands	2590
Plastic operations, tube-flaps, etc.	996
Total operations for carcinoma of mouth, 1923-42	8439

That this large number of cases of buccal carcinoma should have been dealt with in a single hospital of 200 beds in South India is a remarkable fact, and my colleague Dr. I. M. Orr and I studied the subject for some years; Orr (1933) made a survey of some 669 cases, with regard to their habits of betel-nut chewing, their diet, social status, etc., and published the results, including several definite findings which mainly have to deal with the constituents of the betel-nut and its concomitants.

It is not my intention to discuss in this article the question of aetiology, as the findings recorded in the above paper ten years ago still seem to afford a fairly complete and satisfactory explanation of the high incidence of epithelioma of the buccal cavity in certain parts of South India and Ceylon. It may, however, be interesting to summarize them as follows :—

1. Chemical irritation due to the alkaloids produced by the action of lime on the tobacco chewed with the betel leaf and areca nut. The more prolonged this irritation, the more likely is it to lead to epithelioma. Thus :—

2. Poor people who keep their quid of betel in the mouth for a long time (sometimes all night) are more prone to cancer of the mouth than are those who can afford to change the betel-nut at frequent intervals.

3. Vitamin-A deficiency is an aetiological factor, the disease being most common in those areas where diet is most deficient in vitamin A (McCarrison, 1931).

4. The use of lime made from shells is more injurious than is lime made from limestone, owing to its fine division and rapid setting free of the alkaloids from the tobacco. Hence the high incidence of cancer of the mouth in the districts near the sea coast where shell-lime is used.

5. Cancer of the mouth is common only in Travancore, Madras Presidency, and Ceylon, the three areas of India where tobacco is used with the betel leaf. Certain kinds of tobacco, notably the strong Vadakkan tobacco of South India, and the tobacco of Jaffna, Ceylon, are more prone to cause cancer of the mouth than are the milder tobaccos such as those grown around Madura. (See also Snijders and Straub, 1923.)

6. The betel leaf and areca nut are in themselves harmless in this respect. So is the tobacco unless mixed with lime. Orr sums up his results in the following paragraph, taken from the annual report for Neyyoor Hospital in 1936 :—

"Cancer of the mouth is still and probably always will be our really characteristic indigenous disease in Travancore. If the Government were to put an embargo, or a very high duty, on certain kinds—two only—of tobacco, we believe they could cut out with a stroke of the pen some 70 per cent of the cancer in this country. But as the research which has resulted in this finding was performed in a Mission and not a Government institution, it is unlikely that it will be accepted as authoritative in India. Be that as it may, the fact remains that over 500 of our operations each year are for the relief of cancer of the mouth, tongue, jaw, and cheek. And 90 per cent of the disease arises from chewing two kinds of tobacco with the betel nut. The other four or five kinds which are used locally seem to have little or no deleterious effect." Since this was written we have done some 800 operations every year for carcinoma of the mouth, and we have seen no reason to alter or to modify the above conclusions during the ten years that have elapsed since 1933, when this investigation was made.

The aim of the present article, however, is not to discuss the aetiology of this disease, but its treatment. In the course of the last twenty years we have been led gradually to see what is in all probability the best treatment for any particular class of case. In many this is by operation; some are best dealt with by electro-coagulation with diathermy; many require radium; a few should be treated by deep X-ray therapy; and a good number require a combination of two or more of these lines of treatment. As there must be very few hospitals of this size in the world where so many cases of buccal cancer are seen or dealt with, I venture to submit to my fellow surgeons some of the more important points in technique of operation, radium application, etc.,

which we have found out or evolved during these twenty years. We have likewise seen many of the limitations of the various methods of treatment, and have seen disasters, too, both in our own cases and in those of other clinics where the treatment has been wrongly applied.

The work of a hospital in a country district in India suffers from one great drawback, of special importance in dealing with malignant disease. It is almost impossible to follow up cases as we should like to do. Many recurrences go straight to other doctors or hospitals, and we never hear of them again. Many go to quacks and rapidly die under their hands—and we know nothing of their fate. On the other hand, we are constantly seeing the failures of other surgeons and clinics, and a great many of the recurrences we see are from other hospitals. Anything in the nature of complete statistics of our cases is therefore out of the question. We do, however, keep in touch with a certain number of our cases, and we see them often, years afterwards, when they come bringing some other patient for our treatment.

But after all these years, one can at least feel that one has a fairly good idea as to what is the rate of recurrence of each class of case, and one learns in a general way, not by keeping records of figures, what is the relative value of radium, operation, X rays, and their combination, in dealing with these cases. This paper, then, will not be burdened with figures. But of more real value, I maintain, than any set of figures are the general impressions one has obtained, and the improvements in technique of operative methods which we have found out and evolved in the course of dealing with so many cases of cancer of the mouth. Experience rather than statistics, then, must be the foundation of these remarks.

### THE TREATMENT OF BUCCAL CARCINOMA

The habit of chewing betel nut and tucking the quid into the cheek should, we might suppose, affect the cheek and the gums in almost equal proportion. But such is not the case; the gums seem to be more resistant to cancer-producing irritation, so that the greater proportion of our cases begin to show malignancy on the cheek. From the cheek the growth, if neglected (or treated by quack 'physicians', as is the case with most of our patients), spreads in a few weeks to one or both jaws. From the tongue such spread is far more rare, the growth being confined to the tongue itself until a very late stage is reached.

**1. Cheek and Lips.**—In general, it may be said that growths of the cheek are fairly sensitive to radium, except when they are very superficial and of the leukoplakic type. The softer and more fleshy the growth, the more successful is radium likely to be. The harder and more approaching to leukoplakia is the growth, the less effective is radium. For this latter type of growth, we employ an excision with diathermy, followed at once by the insertion of radium needles around

the edge of the growth, a few milligrammes of radium being inserted in the intervening space originally occupied by the growth.

Leukoplakia of the cheek, especially if the Kahn test be negative, is to be looked upon with grave suspicion (Lane Claypon, 1930; Cheatle, 1930). Such cases we invariably treat with diathermy, sometimes also using radium as just described. Leukoplakia of the tongue, however, only appears to become malignant if it is of a very thick and dense type. Stewart (1931) considers that all leukoplakia of the tongue is potentially cancerous, with which I agree; but I should not subject the more harmless looking leukoplakias of the tongue to diathermy if there was the probability of keeping in touch with the patient; the thick variety, however, calls for diathermy and radium, or at least for a biopsy before it is considered safe to leave it.

When radium therapy is given, the dangerous and unknown growing edge is first dealt with, and the intervening space, radiated in part by the cross-fire of the surrounding needles, may require only a few milligrammes of radium. In general, it may be said that radium needles of 1 cm. active length each containing 1 mg. of radium element, if placed 1 cm. apart, should be in a cheek for 10 days. That is to say, each cubic centimetre of epithelioma requires approximately 250 mg.-hr. of radium. This is not a strictly accurate statement, and I prefer personally not to talk or think in 'milligramme-hours'; for double the strength of radium mentioned (i.e., 2 mg. per 1 c.c. active length of needle) has much the same effect in 4 days as the single mg. needles have in 10 days. A 5-mg. needle of 3 cm. active length is just about twice as effective as a 3-mg. needle of the same length. For a soft growth in the tongue or lip or any fungating growth, 1 mg. radium per 1 c.c. of tissue is effective in about 8 days. It is advisable always to add 20 or 25 per cent to the estimated amount of radium, in case of irregularities in the distribution of the needles, or unexpected radio-resistance of the tissue. It is of supreme importance that underdosage of radium should never on any account be given.

Large, fungating growths of cheek or lip can have the fungating part removed by the diathermy knife, in order to save radium, which is used for the non-projecting part of the growth and the tissue immediately around its edge. This method leads to a worse cosmetic result than the use of radium for the entire growth. Some of the normal tissue is destroyed by the diathermy which radium, used alone, would preserve. But by this method more radium is available for the other cases waiting for it in hospital; in our fight with grim death we cannot often think too much of cosmetic results.

It will be noted that in this paper radium is always mentioned as 'inserted' in the form of needles. Considerations have led us to adopt this method of radium treatment almost to the exclusion of all others.

The removal of glands must be done in every case. Glands are always dealt with by operation, though occasionally with the employment of radium as well—i.e., in conjunction with operation, and as a reinforcement to it.

Where cancer of the cheek is very near to the bone of either jaw, radium will very often have to be inserted close to the bone, and a sequestrum will later be formed in some cases, the superficial layer of the bone being killed by the radium.

The extraction of the teeth contiguous to the growth should be done at the same time as the removal of the glands. It should never be done beforehand, or even at the time of insertion of the radium, for cancer cells may become implanted in the sockets of the teeth, and lead to a carcinoma of the jaw some months later. Twenty years ago, when fresh from the teaching hospitals of England, I used to remove teeth in order to clean up the mouth for subsequent surgical procedures; but so often did I notice the occurrence of this implantation-cancer of the jaws, that I gave it up, and never practise it now, however dirty and septic the teeth may be. The teeth are painted over with several coats of iodine, just before operation.

The prognosis of radium-treated carcinomata of the cheek is very good, so long as radiation is sufficient. A small radium burn is not of serious import, and can be treated later by diathermy. Under-radiation, on the other hand, is certain to be followed by recurrence, and the recurrence may be resistant to radium treatment.

Two or three weeks after treatment, the cheek must be examined, and the presence of a superficial ulcer of smooth, wash-leathery appearance extending over the whole of the area originally occupied by the growth (and a little beyond it) means that treatment has been adequate. It is partly in order to keep the patient long enough for this to be observed that I invariably operate upon the glands after, and not before, the growth has been dealt with. The other reason for this is that if the glands draining a cheek are removed before the growth is dealt with, the lymphatic drainage of that cheek will be diverted into new channels, such as to the pre-auricular gland on the same side, or the submaxillary group on the other side, and secondary growths may appear in these situations later.

**2. Lower Jaw.**—The lower jaw is but seldom suitable for the use of radium. Occasionally in patients who have refused operation but submitted to radium treatment, I have been constrained to use radium. But the result has always been the same. If the cancer is destroyed by the radium, the jaw will also have been destroyed, and eventually, perhaps months later, will have to be removed. I remember a tragic case of a fine-looking man who implored me to radiate his lower jaw, and not to operate upon it. I did so, and the cancer disappeared. But the jaw started necrosing, and a few months later had to be removed.

The patient stood this operation well, but developed an abscess of the lung, from which he eventually died. Patients with cancer of the mouth stand one or two anæsthetics well, but not many more, and those requiring a series of operations (such as plastics, etc.) very often develop abscess of the lung after their fourth or fifth operation. For this reason it is my rule to do everything possible in one single operation, and to remove in one block the half-jaw including its condyle, submental and submaxillary glands with the salivary submaxillary, and the large upper deep cervical gland usually known as the tonsillar gland. In most cases this will be sufficient to 'cure' the case—a word I hate to use about cancer, but it will be obvious what is meant. If there be any involvement even of one single deep cervical gland, the case should later have a complete block dissection of the deep cervical area, with part of the sternomastoid muscle and the anterior and posterior cervical glands. The jugular vein can nearly always be preserved, and this should be done, for its removal leads to cerebral congestion in a certain proportion of cases, many of which eventually die from it a few days after operation. If the vein has been adherent to the glands, a few radium needles should be inserted alongside it at that place immediately the operation is finished and before the skin is sutured.

With regard to the anæsthetic to be employed, we have found in South India that chloroform on an open mask is a very safe anæsthetic. In the warm climate, a fair amount of chloroform evaporates into the air, giving a greater margin of safety. In many thousands of cases anæsthetized by open chloroform at this hospital, we have had practically no deaths from overdose or in other ways directly attributable to the anæsthetic. The feeding up of patients before operation, and the administration of an ounce of sugar with 60 gr. of sod. bicarb. a couple of hours before the anæsthetic is given, has entirely eliminated the danger, at one time so real, of post-chloroform acidosis. Moreover, when a laryngotomy is performed, chloroform can be so easily administered by a Junker bottle. So it has come to be our anæsthetic of choice. We have experimented with other anæsthetics for jaw cases, especially with the two following:—

*a. Basal paraldehyde* by the rectum, with injection of novocain into the foramen ovale and complete local block anæsthesia, is theoretically sound, though laryngotomy is distressing to a conscious or half-conscious patient, and without it the difficulty and danger of the operation of excision of the jaw are materially increased. We occasionally give this method of anæsthesia in cases such as diabetics or 'chesty' individuals who are unsuitable for chloroform. In a series of 100 lower-jaw excisions anæsthetized by this method, we found no improvement in our mortality or morbidity figures as against simple chloroform.

*b. Rectal ether* in olive oil, with or without local novocain, has its advantages, but it, too, seems to produce lung complications as frequently as chloroform. We did a series of over 150 with rectal ether; and other methods have been tried, but we have not found that our mortality, immediate or remote, is materially cut down by any particular method. Even in the best hands, the excision of the lower jaw is a severe operation, performed as it usually is on old people with oral sepsis; whatever be the method of anæsthesia, a surgeon must be thankful, and so must his patients, if less than 10 per cent mortality results from the operation.

Immediately the patient is sufficiently under to lose reflexes, laryngotomy is performed, and the throat is packed with gauze; a single swab about 4 in.  $\times$  8 in. of 16 thicknesses of gauze is usually sufficient. The laryngotomy tube is left in, at the discretion of the nurse in charge of the case, for one or more days (not more than four) after the operation.

**3. Tongue.**—The tongue exhibits a greater variety of lesions of the epitheliomatous type than do the cheek and jaws. Each variety has its own special methods of treatment, but on the whole it may be said that every case of cancer of the tongue is best treated by the insertion of radium needles, though in a few situations operation is required as well.

*a. Side of the Tongue.*—This is the most usual site for carcinoma, and is nearly always the easiest site to treat. Radium needles are inserted in pairs. I use a 4-cm. needle of 2-mg. strength, active length 3 cm., inserted into the front of the tongue, and anchored there by being tied to a 1-in. ( $2\frac{1}{2}$ -cm.) needle of 1-mg. strength and active length  $1\frac{1}{2}$  cm., inserted into the back of the tongue. As many pairs of needles as are required by the size of the growth are inserted in this way, as shown in the figure (Fig. 24). If the radium

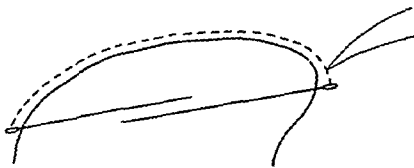


FIG. 24.—Radium needles inserted in pairs into tongue.

available admits of only 1 mg. of radium element per 1 c.c. of cancer tissue, the needles will have to be left in for ten days. Double this strength, however, for half the time, is preferable. Most of the needles are inserted at the border of the palpable growth, or just outside it; a few may have to be inserted into the substance of the growth, in which case precaution must be taken that their points do not penetrate beyond the growth into normal tissue. The threads of the radium needles are anchored by a stitch of strong

catgut inserted into normal tissue near the tip of the tongue, and made to pass through a rubber tube, to prevent the patient from biting them off; they are all further fixed by a stitch of strong thread to the cheek.

If the growth is entirely confined to the one side of the tongue, a unilateral block dissection of submental (bilateral), submaxillary, and deep cervical glands, as far down as 2 cm. below the omohyoid muscle, is sufficient. The glands of the posterior triangle need not be removed unless there is involvement of any of the glands beneath the sternomastoid muscle. Observation must be kept on the glands of the other side; if any of them become involved, operation combined with implantation of blunt-pointed radium needles around the main vessels is usually the treatment of choice.

I am not in favour of subjecting the glands in tongue cases to X-ray therapy except when they are fixed, or when the carotid artery seems to be adherent to the growth or involved in it. The effect of deep X rays on the patient's physical and psychological condition is sometimes very sinister.

*b. Tip of the Tongue.*—This is hard to radiate well, and a carcinoma involving only the tip is best removed with diathermy, with radiation of the base of the wound with short needles inserted transversely.

*c. Back of the Tongue.*—This may be the seat of a large, soft growth, which sometimes extends down to the epiglottis. This type of growth is very radio-sensitive, but if it is very soft it is difficult to persuade radium needles to remain in it for long, and longish needles with high dosage for a short time is the ideal treatment. These carcinomata must be dealt with very gently; small fragments of the growth, if they should be inhaled, will produce secondary growths in the lung, a type of growth which is not treatable by deep X rays with much hope of success. Radical removal of glands on both sides must be carried out. Note that long radium needles can be inserted into the back of the tongue from just below the mandible, between the facial artery and the angle of the jaw.

*d. Floor of the Mouth.*—This is often involved in tongue cancer, and radium can be inserted both within the mouth, parallel to the long axis of the tongue, and from without, just inside the edge of the mandible. These needles should point vertically upwards. Some sequestration of the inner surfaces of the mandible may very probably occur. The deep cervical glands are removed later; the glands of the submaxillary and submental groups will probably have been adequately radiated by the needles put in from outside, but if any doubt is felt about this, they should, of course, be removed. After the radium needles have been taken out, small incisions below the mandible for drainage may have to be made, for infection of the submaxillary spaces is almost bound to have occurred.

*e. Epiglottis and Extreme Back of Tongue.*—This is a difficult situation to treat; radium needles inserted from without, near the angle of the jaw, offer the best chance of cure. The upper deep cervical glands, including those beneath and behind the mastoid process, are apt to be involved early, and sometimes the carotid artery is found to be adherent to the glands. Thus, in these cases, deep X-ray therapy may be indicated. The danger of removing such glands, combined with the use of radium, is twofold—infection of the carotid sheath, leading to mediastinitis; and secondary hæmorrhage from the carotid artery.

*f. Tonsil Region.*—Unless the growth is reported early, the tonsil is a dangerous site for carcinoma or sarcoma. As in the case of the epiglottis, the deep glands are likely to be involved at an early stage, so that there may be a cancerous block of tissue including tonsil, glands, and the main vessels. Deep X-ray therapy, combined with the radiation by insertion of long radium needles into the deeper parts of the growth, and into the tonsil itself, offers a chance of cure. X rays of 400 kv. and over are necessary for this type of case; a smaller voltage will not suffice to penetrate the deeper regions of the mass of growth. It is only in early cases that the insertion of radium needles into the growth, and operation on the glands, is a proper form of treatment. I have done two cases of this nature with successful results for two years at least, using only radium for both growth and glands. For carcinoma of the tonsil, long radium needles can often be satisfactorily inserted into the tonsillar region from without, just in front of the ramus of the mandible, pushed well in beneath the mucous membrane and the anterior pillar of the fauces until their active part reaches the tonsil.

*g. Whole Tongue.*—When the tongue is badly involved in carcinoma, so that it is fixed, and cannot be protruded, it is usually best to remove the whole tongue, after a preliminary laryngotomy. Some growth will usually be left, or at least suspected, in the floor of the mouth, and the whole of this region is treated at once with radium, inserted from outside, in the submental and submaxillary areas. These cases if thus dealt with often do surprisingly well. Glands must, of course, be removed radically on both sides, and care must be taken to preserve at least one, if not both, the jugular veins. For this purpose a combination of operation and radium treatment is necessary.

*General Principles.*—It is important to avoid whenever possible the insertion of two or more separate lots of radium.

The first insertion may produce radio-resistance to an extent which cannot be gauged; the dosage for the second insertion is then almost impossible to guess accurately. Complete treatment by one insertion of radium, combined if necessary (as in the case of the whole tongue) with operation, must be done at one sitting if possible. The tongue stands both radium and

diathermy well, and growths in its substance are usually very radiosensitive. A hard, leukoplakic growth, however, is best removed by diathermy, as in the case of the cheek. Radium is then inserted in the bed of the growth, as a safeguard, at the same sitting. Radium burns must be treated; in every case a biopsy is required to make sure they are radium burns, and not recurrences; burns are treated by cautery with the diathermy—this also produces a burn, but one which heals well, and is much less painful than is the average radium burn.

**4. Upper Jaw.**—When this is involved in cancer spreading from the cheek, the alveolar and palatal part of the jaw is usually affected; the antrum is often free from growth, and the orbital floor is quite uninvolved. In these cases, the jaw should be removed by operation.

**5. Glands.**—If the growth and glands cannot be removed at the same time, it is a sound general principle to operate on the glands only after the growth has been either removed or rendered innocuous by radium.

There is a risk, of course, of the patient running away before the glands are dealt with; but that can often be avoided by pretending that an anæsthetic is necessary for the extraction of the radium needles, or by keeping the patient unnecessarily in bed. The greater risk is run by dealing with the glands before the growth is operated upon; the growth, being still active and in situ, develops new lymphatic drainage, and may involve a new group of glands. For instance, a cancer of the cheek normally involves the submental and submaxillary glands; if these are removed lymphatic drainage is diverted to the pre-auricular gland, the lymphatic gland in the lower pole of the parotid, and even to the submaxillary glands on the other side or the deep cervical group on either side.

During the first few years of my life in India I used to operate on the glands before the growth; but this transference of the drainage to other groups of glands, and the appearance of cancer in them, occurred so often that I soon gave it up, and I never do it now except under strong indications.

With regard to the question of which glands should be removed, this depends, of course, to some extent on their involvement. Cancer of the cheek region, including lips and jaws, tends first to involve the submental and submaxillary groups, and an isolated gland near the common facial vein. Very occasionally the tonsillar glands in the upper deep cervical group are involved. Beyond the glands mentioned there is a layer of fascia which, though in places very thin, acts as a boundary for sepsis; it is safe to remove all these glands in a lower-jaw operation, without risking infection of the carotid sheath and its serious sequel of anterior mediastinitis.

In the cheek, lip, or jaw case in which there is no palpable enlargement of any glands at all, it is sufficient to remove this group. In an early

cheek case I remove only the submaxillary and submental glands, but always at least these two groups, the submental group being dissected out with the diathermy knife. If there is involvement of only a few of the submental or submaxillary glands, the upper deep cervical glands must also be removed, and the case must be kept under observation. A complete block dissection of the neck is a risky operation to a patient who is either septic or debilitated by a previous removal of a lower jaw, and the relative risk of leaving the glands behind, and of subjecting the patient to a  $\frac{3}{4}$ -hour anæsthetic or a risk of mediastinitis must be weighed. Radium can sometimes be used to attack these glands if a block dissection is considered too dangerous.

In the case of the tongue, a relatively much more extensive gland operation must be done. As a routine, if no palpable involvement of glands can be made out, and the cancer is of fairly small size and confined to one side of the tongue, I make a practice of removing submental, submaxillary, and deep cervical (anterior) glands down to the omohyoid muscle. If at operation any of these are found to be involved, the operation is extended. The incision is extended down to the clavicle (Fig. 25, A) over the sternomastoid muscle; this muscle is defined front and back, isolated from the jugular vein in the middle third, and divided just below the spinal accessory nerve. The two halves are retracted up and down, and an excellent view of the glands beneath it is obtained. These are all removed, together with adherent muscle or vein. The vein is only removed if its compression produces no symptoms and if it is really adherent to glands. It is safer to leave it behind if it is very large, and to peel the glands off it, leaving radium needles along its length of a suitable dose, usually about 14 mg. for eight days. If any single deep cervical gland is found to be enlarged and obviously malignant, a complete removal of all deep and posterior cervical glands should be done. An extension of the incision over the brachial plexus region (Fig. 25, B) may be required.

In a lower-jaw case this extensive removal, if found to be necessary, should only be done when the jaw operation has healed sufficiently well to render the danger of sepsis in the carotid sheath fairly remote; drainage of the lower end of the wound is necessary for a few days, in case any sepsis should occur, and to prevent mediastinitis.

The upper jaw drains into the pre-auricular, parotid, buccal, and submaxillary glands and only these glands need be removed unless any involvement of them indicates that a wider removal is advisable. These cases must always, if possible, be observed at least once a month for six months, and thereafter once every two or three months for two years.

#### 6. Carcinoma in Certain Special Situations.—

a. Involvement of the lower jaw with a very extensive carcinoma of the cheek indicates a

preliminary radiation of the cheek and upper part of the growth, and removal of the lower jaw by operation. Conversely, an operable upper jaw

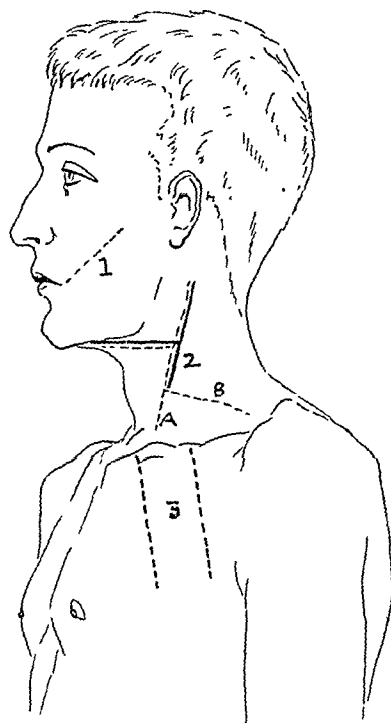


FIG. 25.—Incisions for: (1) Upper jaw, alveolar part; (2) Glands of neck, upper glands only, A and B being extensions; (3) Tube flap.

combined with a fairly extensive carcinoma of the cheek demands radiation of the cheek and removal by operation of the upper jaw.\*

b. Carcinoma in the angle between the jaws is best treated by radium at first; the lower jaw, if necrotic, may have to be removed at a later date.

c. Carcinoma of the tonsil is the most fatal of all buccal carcinomata, owing to its early involvement of the deepest cervical glands.

d. Carcinoma of the epiglottis, another very fatal variety.

e. Carcinoma of the back of the nasopharynx and ethmoid region is very rare. I have only seen 6 cases. It is best treated by radium. If the extent of the growth is doubtful, a partial excision of the upper jaw may be advisable in order to carry out thorough observations of the growth, which is particularly liable to escape thorough radiation if care is not taken. Of 2 cases I radiated without operation, both died. One case which I treated with radium had had deep X-ray therapy one year previously in Madras; she died 2 years after beginning of

\* In both these cases, the upper incision of the lower-jaw operation or the lower incision of an upper-jaw operation has to be made boldly through radiated growth.

treatment. Three cases were treated with radium insertion after partial excision of the upper jaw. One is alive 10 years after operation; of the others one is untraced and one is alive 3 years after operation.

Though this is but a small number of cases on which to base dogmatic statements, the results

**Mortality (Table III).**—In this series of cases it must be remembered that many hundreds of cases have been dealt with which I was brought up in London to consider inoperable. The death from cancer of the mouth is so horrible that many patients ask me to operate on them "even if it will kill me", and if thus invited to do so, I

Table III.—TABLE OF MORTALITY OF OPERATIONS FOR CANCER, 1923-1942

SITE OF GROWTH	NO. OPERATED	DEATHS WHILE IN HOSPITAL*	PERCENTAGE	REMARKS ON CHIEF CAUSE OF DEATH
Cheek and lips	2533	5	0.2	—
Tongue	633	12	2.0	Pneumonia
Upper jaw	349	12	3.4	Secondary hæmorrhage and pneumonia
Lower jaw	1338	114	8.5	Pneumonia, abscess of lung
Glands in neck	2590	13	0.5	Cerebral congestion
Plastic operations, etc.	996	2	0.2	Abscess of lung
<i>Situations other than Mouth</i> —				
Breast and glands	113	3	3.0	—
Penis and glands	171	2	1.3	Secondary hæmorrhage, femoral
Rectum	48	4	8.3	Operation shock or sepsis
Larynx and pharynx	62	4	6.5	Mediastinitis
Cervix (mostly radium cases)	558	11	2.0	Mortality confined to hysterectomy cases. No deaths from radium treatment alone

\* Includes deaths as an immediate result of operation, or during the first few weeks after operation. The large majority of the deaths except in the rectum cases fall into the latter category.

are sufficiently definite to make me feel that in carcinoma of the nasopharynx the routine treatment should be by radium after excision of the hard palate on one side, with the alveolar part of the jaw, leaving the orbital floor and the anterior wall of the antrum, but removing the inner wall of the antrum and the lower turbinate. This enables excellent observation of the growth to be made throughout its treatment and after. Recurrences are thus "caught in time", and a dental prosthesis filling in the gap in the palate and the alveolar portion of the jaw can be supplied a year or so after the operation. This can be removed as often as is required for observation of the site of the growth. A few days after the excision, radium needles can be applied, under direct observation, to the growth.

**Plastic Operations.**—Many cases of cancer starting in the cheek will require removal of a large piece of the cheek, leaving a gap; in lower-jaw cases especially is this frequently necessary. After the wound has attained a healing condition, i.e., when the size of the inevitable gap is apparent, plans must be made for its closure by plastic operations. The inner side of the cheek must be formed either by mucous membrane or by skin. In women, this skin can often be supplied by turning in flaps from the edge of the gap, or by a sliding flap. In men this is rarely possible on account of the hair on the skin, and for most male and some female cases a tube-flap from the chest is necessary. The base of the tube is best at the clavicle; the distal end should lead to hairless skin between the nipple and the axilla; the two incisions isolating the tube must provide a good tube, and must therefore be in no place less than 2 in. apart. (Fig. 25, 3.)

usually obey the call of humanity and neglect that of statistics. The appended table shows the mortality of the various types of epithelioma mentioned in these pages, the cause of death being hardly ever operative shock, but nearly always pneumonia, abscess of the lung, or congestion of the brain following ablation of the internal jugular vein.

**Radium versus X Rays and Operation.**—I have seen so many tragedies caused by the treatment of cancer of the mouth with X rays that I am very doubtful of the advisability of treating any case of carcinoma of the buccal and nasopharyngeal cavities with X rays. Nearly every one of the cases I have been personally in touch with which have been treated by deep X-ray therapy have eventually had a recurrence of the growth either locally or secondarily, or have had insufficient radiation of some part or other of growth or glands. In addition to this, X-ray therapy always has some ill effects on the general health of the patient, and these effects may be profound in some cases, reducing them to a condition in which they cannot stand the further treatment, perhaps involving anaesthesia for radium or operations, which may be necessary for their cure.

The ability of X rays and radium to cause the start of a new growth if a certain dosage be given is also a factor to be considered. These secondary new growths develop only in certain few individuals, as a response to a dose of X rays or radium which probably varies with the individual. In cases of carcinoma of the cheek or tongue which have been treated with radium of correct dosage, by insertion of needles, I have noticed that carcinoma, if it develops in this way, starts



approximately 4 to 5 cm. from the edge of the radiated primary growth, at least six months after the radiation is done. It appears to occur in this way in only 1 per cent or less of cases.

On the whole, I would appeal for operation to be the normal recognized treatment for all cases of carcinoma of upper and lower jaws. Radium is the best treatment for cancer of tongue or cheek, in conjunction, as already mentioned, with diathermy or operative removal of certain types of growth such as large fungating growths, cancer of the whole tongue, and epithelioma of the leukoplakic type in tongue or cheek.

**A Final Word.**—Operation has not the unpleasant after-effects of radiation, and is always the method of choice except for tongue, cheek, tonsil, and a few special situations. An operation which is felt during its course to be insufficient can always be reinforced by radium. Deep X-ray therapy is very disappointing in mouth cases. Radium when used must be used in sufficient doses. Just as in the political sphere, so in dealing with cancer, whether by radium or operation, it must always be remembered that error on the side of radicality is always safer than error on the conservative side. One cancer cell left behind will kill the patient; a small radium burn or a little extra mutilation may mean inconvenience, but may mean a life saved.

Another point I would stress is this: All surgeons who operate upon cancer patients should be conversant with the practice and principles of radium treatment. I deplore the separation of so-called 'radium' clinics or institutes from the surgical side in general hospitals. The radium expert and the surgeon should work hand in hand, and the former should always be prepared to make some radium needles available for the surgeon to use at the time of operation if necessary, especially in cases of cancer of the jaws. It is hard to remember a week or two later exactly what parts of the operation area needed reinforcement with radium; it is easy to insert a suitable dose of radium exactly where it is wanted while the case is still on the operating table.

Finally, I feel that we should always remember that our duty is to relieve suffering, and often we ought to put that before the actual saving of life. If euthanasia is to be the probable effect of an operation, it may be the right thing to do it, and is in my opinion, always better than insufficiency or neglect. Perhaps that consideration may make our operations more radical and more effective. There is no excuse for a surgeon who does a shoddy or insufficient operation for malignant disease, least of all in a hospital where radium is available to reinforce operative deficiencies. "He's had about enough; we had better

leave that little bit", said with the kindest of motives, in order to save an extra 2 per cent of risk of mortality, may mean the death sentence of the patient.

## SUMMARY

A series of nearly 5000 cases of carcinoma of the mouth and jaws, involving over 8000 operations, is reviewed mainly in the light of answering the question: "What is the treatment of choice, operation, X rays, or radium?"

Operative technique based on over a thousand personal cases of operations for carcinoma of mandible and maxilla is described.

The treatment most suited to various groups of cases is discussed with reference to epithelioma of (1) cheek, (2) lower jaw, (3) tongue, (4) upper jaw, (5) glands of the neck, (6) certain special situations.

A brief description is given of some plastic operations essential for the filling up of facial defects left from cancer operations.

The relative value in buccal carcinoma of X rays, radium, and operation is assessed.

An appeal is made to surgeons to co-operate much more intimately with radium departments than is usually the case.

In the writing of this paper I acknowledge with thanks the permission of the editors of the *Indian Journal of Surgery*, who allowed me to quote freely from an article on this subject which I recently published in that journal (1943). I wish to thank also my colleagues on the medical and nursing staff of the Neyyoor Hospital, whose co-operation in the treatment of cancer has saved so many lives, and continues to do so. In particular I may mention Dr. I. M. Orr, my collaborator for nine years, whose researches on the aetiology of this type of cancer have been quoted; my colleague, Dr. N. E. James, who is at present in charge of our male cancer wards, and who has helped with suggestions; and Mr. Rajiah, who has copied my original drawings in a form suitable for reproduction.

## REFERENCES

- CHEATLE, LENTHAL (1930), *Cancer Rev.*, 5, 81.  
 CLAYTON, LANE, SIR R. (1930), *Ministry of Health Reports*, No. 59.  
 MCCARRISON (1931), *Brit. med. J.*, 1, 966; *Ind. J. med. Res.*, 19.  
 MELLANBY, E. (1939), *Recent Advances in Medical Science*, 46.  
 ORR, I. M. (1933), *Lancet*, 2, 575.  
 SNIJERS and STRAUB (1923), *Trans. Congr. Far-East. Ass. trop. Med.*, 779.  
 SOMERVILL, T. H. (1943), *Ind. J. Surg.*, 2, 5.  
 STEWART, M. J. (1931), *Lancet*, 2, 565.



## INJURIES OF THE URINARY BLADDER\*

By J. COSBIE ROSS, LIVERPOOL

*Cui persecta vesica . . . lethale est.*—Hippocrates.

THE gloomy prediction of the Father of Medicine has thrown a dark shadow over the subject of injured bladder throughout the centuries, and this shadow has persisted up to the present time.

Injury of the bladder is not a common condition in civilian emergency surgery, but the incidence rises as a result of the numerous penetrating wounds of modern warfare. The short series of cases described below occurred within a brief period, and each case was a classical example. A further point of interest lies in the

injuries. Of a series of 60 cases no less than 40 had an accompanying fracture of the pelvis, and Tanton (1918), quoted by McAlpine, found only 55 uncomplicated cases against 312 in which fracture of the pelvis was also present.

**State of the Bladder.**—A full bladder is undoubtedly more prone to injury than one lying empty deep down in the pelvis. Larrey (1829), who as Napoleon's surgeon-general must have had a wide experience of wounds, pointed out this fact over a century ago.

A full bladder presents a larger target than the empty organ, and if projecting above the pubis may be injured by a penetrating wound without damage to the bony pelvis (Fig. 26).

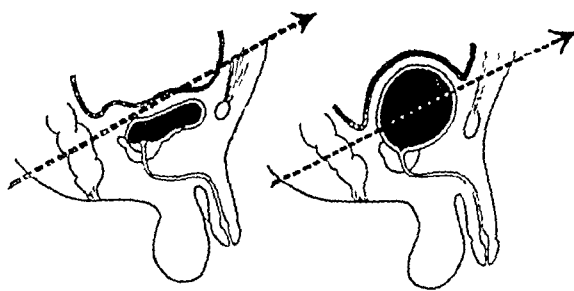


FIG. 26.—Illustrating the vulnerability of the distended bladder.

fact that there were no deaths. This sharply contradicts the view of writers previous to the Great War of 1914-18, who considered that any abdominal injury subjected to operation died; and also that of the older writers who thought that no case of rupture of the bladder ever recovered. In a series of 965 cases of abdominal injury sustained in the last war, and analysed by Wallace (1917), the bladder was injured on 45 occasions, or 4.66 per cent. Fullerton (1918) was only able to collect a series of 53 cases.

Civil injuries are dealt with at some length by American authors, who all emphasize the rise of incidence due to automobile accidents. Cahill (1937) records 20 bladder injuries in a series of 9900 consecutive urological cases admitted to his hospital; and of 74 individuals suffering from injuries of the urinary tract, Marquardt and Cook (1940) found 19 per cent involved the bladder. In discussing 53 cases of subcutaneous injury of the abdominal contents, W. E. Cody (1939) reported that rupture of the bladder occurred in 5 instances, compared with rupture of liver 12 cases, rupture of spleen 11 cases, rupture of kidney 9 cases, and laceration of renal vessels 1 case.

As might be expected, fracture of the pelvis is also present in the great majority of bladder

## TYPES OF INJURY

The three main injuries are contusions, wounds, and rupture (Hinman, 1935).

**1. Contusion.**—This is rare and is difficult to recognize. It is usually due to a prolonged and difficult labour, produces injury of the trigonal muscle, and may eventually predispose to the formation of a cystocele.

**2. Wounds.**—These are generally of military origin and frequently of the penetrating type, although an occasional case of injury of the bladder during hysterectomy, especially vaginal hysterectomy, has been recorded. A punctured wound may temporarily seal itself off as bullets tend to split the muscular fasciculi. Of Fullerton's 53 cases, in 4 cases wounds were situated in the suprapubic area, in 34 the wound of entry was in the region of the buttock, and in 5 the exit was similarly situated. Thus, in 39 out of 53 cases (75 per cent), a wound communicating with the bladder was found in the buttock area.

In many instances the foreign body is retained, and in 10 out of the 53 cases was found in the bladder.

**3. Rupture.**—Inebriation is a well-known predisposing cause when combined with a sharp blow on the hypogastrium. Not only is the bladder overdistended, but the abdominal musculature is not on guard. This is well illustrated by Case 2 of the series. Apart from this, rarer causes are:—

- a. Rupture during parturition.
- b. Overdistension during cystoscopy.
- c. Injury by lithotrite, by excessively deep diathermy, or by the resectoscope.
- d. Spontaneous rupture of a distended diseased bladder. (Crosbie, 1924.)
- e. Spontaneous rupture of a normal though distended bladder (Barnes and Steele, 1935; Chisholm and Ferguson, 1939; E. H. Fenwick, 1886).

\* Hunterian lecture, Royal College of Surgeons, April, 1943.

- f. Secondary to osteomyelitis of the pelvis.  
 g. Secondary to stricture of the urethra (Keen and Goldschlager, 1938).  
 h. Secondary to manipulation for fractured pelvis (Cahill, 1937).  
 i. Trivial falls, lifting strains, or muscular exertion.

Stirling (1936) points out that a blow on the abdominal wall may cause an extraperitoneal rupture, the bladder bursting posteriorly if partly filled; if the bladder is very full an intraperitoneal rupture occurs upwards (Fig. 27).

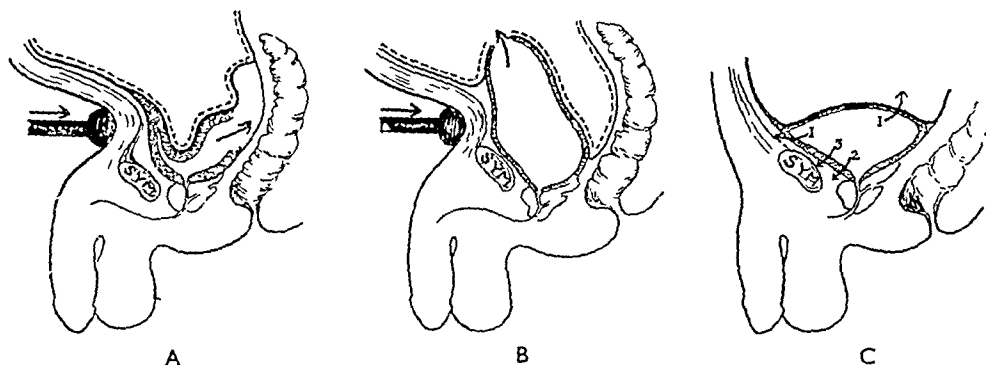


FIG. 27.—A, Extraperitoneal rupture of a partly filled bladder; B, Intraperitoneal rupture of a full bladder; C, Common sites of rupture.

In his opinion a common injury is an extraperitoneal rupture into the space of Retzius, and this is attributed to the thinning out of the muscular wall of the bladder just above the pubis (Fig. 28).



FIG. 28.—The thinning of the muscular wall of the bladder just above the pubis (after Stirling).

The writer carried out a series of experiments on the cadaver in this connexion. Unfortunately however, the factors of muscular tone of the bladder and the abdominal wall, and of rigor mortis, appeared to render the results of doubtful value. For what it is worth, overdistension of the bladder in the cadaver usually results either in an intraperitoneal rupture upwards, or an extraperitoneal leak into the space of Retzius.

#### CLINICAL CLASSIFICATION

This includes intraperitoneal and extraperitoneal injuries. Penetrating wounds of the abdomen usually cause intraperitoneal lesions,

while missiles entering the pelvis via the buttocks, thighs, or perineum are more likely to be extraperitoneal. Intraperitoneal injuries usually affect the dome and posterior wall of the bladder and lead eventually to peritonitis. Extraperitoneal lesions are situated either anteriorly, laterally, or at the base of the bladder, and produce extravasation of urine and pelvic cellulitis.

Tanton (1918) found that extraperitoneal injuries are four times more common than intraperitoneal, whereas in civil cases Hamilton Bailey (1940) states that 80 per cent are intraperitoneal.

Some authorities claim that in mining districts the percentage of extraperitoneal injuries rises with the frequency of fractures of the pelvis.

#### COMPLICATIONS

The majority of bladder injuries are complicated by injuries, sometimes even more serious, of other organs. Of the 45 analysed by Sir Cuthbert Wallace (1917) 25 were uncomplicated, but of Tanton's 312 cases in only 55 was the bladder the only viscus damaged.

Fullerton's 53 cases were complicated by the following additional injuries :—

Bladder, pelvis, and rectum	11
Bladder, pelvis, rectum, and small intestine	2
Bladder and pelvis	9
Bladder and rectum	8
Bladder and small intestine	4
Bladder and pelvic colon	1

Practically all extraperitoneal injuries are associated with fracture of the pelvis, the horizontal ramus of the pubis being the part most commonly involved.

In general, intraperitoneal injuries are associated with peritonitis, and extraperitoneal with pelvic cellulitis. It has, however, been commented upon by several writers that there may be little evidence of peritonitis even after the presence of urine in the peritoneal cavity for a considerable period, e.g., three and a half days on one occasion. In practically every case of bladder injury some degree of cystitis supervenes ultimately.

Other complications include :—

1. Extravasation of urine.
2. Epididymitis. (See Case 1.)
3. Renal infection.

4. Osteomyelitis and necrosis of the bony pelvis. If the acetabulum is thus involved, the hip-joint may be infected.

5. Anaerobic infection, especially of the abdominal wall.

6. Secondary hæmorrhage.

7. Fæcal fistula.

8. Rectovesical fistula.

9. Intestinal obstruction.

10. Gangrene of the bladder wall (P. C. Fenwick, 1910).

### PROGNOSIS

This has always been regarded as extremely grave, but it is one purpose of this paper to suggest that with modern methods of resuscitation, combined with chemotherapy, the prognosis may not be as serious as has been thought before such methods were available. In *Case 1* the intravenous administration of plasma was particularly helpful and probably life-saving.

In uncomplicated cases the mortality has been estimated as greater than 50 per cent. The prognosis in intraperitoneal lesions is obviously graver when small intestine is involved and the "picture is dismal in the extreme; in sixteen instances there was only one recovery". (*British Official History of the Great War*, quoted by McAlpine.)

The importance of early operation is emphasized by Hamilton Bailey when discussing civil injuries. He points out that the mortality is 11 per cent if the operation is carried out within twelve hours of the injury, 55 per cent if operation is delayed for twenty-four hours, and 100 per cent if no operation is performed. It is evident, however, that the accompanying complications are also vital factors, and that their presence or absence influences the final outcome to a great extent. Again, the time factor is not always the keynote; this is well shown by *Case 3*, where operation was not carried out until several days had elapsed and pelvic cellulitis had supervened. In fact, in this case there was at first no direct evidence of injury of the bladder, and the diagnosis was not made before cystoscopy had been performed.

### CLINICAL FEATURES

**Intraperitoneal Injuries.**—While many cases exhibit a high degree of shock, this is by no means an invariable accompaniment. The clinical features are conveniently divided into two stages:—

1. *During the first twenty hours:* Severe shock and pain are accompanied by the desire to void urine, but inability to do so. There are also symptoms of peritonism, slight generalized abdominal distension, and some degree of rigidity. Free fluid is present.

2. *After the first twenty hours have elapsed:* Signs of generalized peritonitis, and perhaps ileus, supervene.

**Extraperitoneal Injuries.**—Shock is not so marked, but strangury is usually a feature. It

is important to distinguish this condition from rupture of the posterior urethra, when the distended bladder can be readily felt. Later, pericystitis is followed by the development of an abscess which may point in the space of Retzius. If the bladder has received an extraperitoneal injury due to a foreign body entering from the buttock, it is uncommon for the diagnosis to be clinched by the leakage of urine along the long track. On the other hand consideration of the ports of entry and exit may be helpful, and an X-ray examination is most desirable if time and the patient's condition permit.

### DIAGNOSIS

American writers (Shipley and Hamrick, 1938) emphasize the importance of four cardinal features in making a diagnosis: (1) History of injury in the bladder region; (2) Presence of shock; (3) Inability to void urine; (4) Blood obtained on passing a catheter.

Stirling adds to these the presence of a 'tumour-mass' in the suprapubic region in extraperitoneal cases.

Among the various diagnostic methods advised in this connexion, the use of an intravenous pyelogram appears innocuous, and if time and facilities are available may prove very helpful, if not diagnostic. Recently, this procedure was valuable in excluding a bladder lesion in a case of abdominal injury. The suggestion that the bladder should be filled with 2 per cent sodium iodide through a catheter, and subsequently X-rayed, seems to bristle with objections. Similarly, the injection of air through a catheter for the purpose of obtaining a pneumocystogram has only to be mentioned to be condemned. These suggestions appear to be of theoretical interest rather than of practical application.

On the other hand, a plain radiograph to localize foreign bodies and to indicate fracture of the pelvis is indicated, if time, facilities, and the patient's condition permit (*see Case 3*). As in some cases the fæcal fistula, if one is present, communicates with the rectum, sigmoidoscopy may be helpful under certain circumstances.

The two diagnostic methods about which controversy has raged are catheterization and cystoscopy.

**Catheterization.**—McAlpine (1940) points out that the passage of a catheter will demonstrate:—

1. The patency of the urethra.  
2. Perhaps distension of the bladder, and therefore no leakage (*see below*).

3. Absence of more than a drop or two of urine suggests that the bladder is perforated. An empty bladder suggests an intraperitoneal leak.

4. Perhaps pure blood or blood-stained urine. Hamilton Bailey advises the passage of a catheter only when in the theatre, with all preparations made for the operation should this be necessary. He suggests the following technique

if blood or blood-stained urine is withdrawn: The patient is immediately placed in Fowler's position and 12 oz. of saline are introduced through the catheter; if *all* the saline is not recovered, injury of the bladder is indicated.

On the other hand, Oehlecker (1912) drew 7 litres of fluid from a catheter that had passed through the vent in the bladder into the peritoneal cavity.

Fullerton also reports a case where 30 oz. of clear urine were withdrawn through a catheter and so misled the surgeon that the diagnosis was seriously delayed.

The great danger of passing a catheter is of spreading infection, but this danger is probably outweighed by the diagnostic help obtained, especially if adequate precautions are faithfully observed.

**Cystoscopy.**—Opinion has been against attempting cystoscopy in these cases up to the present, but it is the present contention that if used with care cystoscopy causes no more danger than catheterization, and, as is shown in *Case 3*, sometimes the diagnosis cannot be made by any other method. In support of this may be mentioned Neligan's (1941) view that if there is reason to suppose that the damage to the bladder is extraperitoneal, cystoscopy will do no harm and may be helpful. Stevens and Dalzell (1937) state that cystoscopy will give a positive diagnosis in 85 per cent of cases, and that provided subsequent operation is prompt, it does not add to the risk.

The position may be summarized thus: if it is justifiable to insert a catheter and to inject saline, it is certainly permissible to carry out a cystoscopy, which will incidentally provide much more valuable information. It is obvious, however, that in certain cases the diagnosis will be so evident, and the condition so urgent, that these measures will be at once unnecessary and dangerous.

### TREATMENT

McAlpine emphasizes four main principles of treatment: (1) Excision of wound; (2) Suture; (3) Drainage of the bladder; (4) Drainage of cellular spaces of the pelvis.

**Intraperitoneal Injuries.**—A midline incision is usually made, but occasionally it is possible to use the surface wound. In *Case 1* the wound of exit was utilized. Urine and blood are either mopped up or removed by suction and the table is placed in Trendelenberg's position. The interior of the bladder must be inspected in order to exclude a retained foreign body or a second wound. Wounds of the posterior wall and dome are excised and sutured, the serous coat permitting a sound, watertight union, especially if a double row of sutures is used. Wounds deeply situated can sometimes be best dealt with from within the bladder. Other damaged abdominal viscera must be repaired, and the peritoneal cavity should be carefully

closed, with or without drainage. The extraperitoneal part of the bladder is fully explored, and a suprapubic drainage tube is desirable. This is probably safer in male cases than relying entirely on an indwelling catheter.

**Extraperitoneal Injuries.**—It is most important to ensure that there is not also an intraperitoneal lesion. A suprapubic incision is made and the four principles enunciated above are applied. McAlpine has pointed out that the lateral walls and base are unsuitable for excision and suture owing to difficulty of access and to the perivesical fibro-fatty tissue which fixes the bladder wall. In these situations, therefore, excision may be omitted and suture alone carried out. It is especially important to institute suprapubic drainage and also drainage of the cellular spaces of the pelvis.

Fistulae between the rectum and the bladder are favourable and tend to heal well provided cystostomy, using a wide drainage tube and not a de Pezzer catheter, is combined with a transverse colostomy. In Legueu's (1919) series of 60 bladder injuries 20 were complicated by a rectal wound, and, of these, 18 fistulae healed within eight months of the injury.

### CASE REPORTS

*Case 1.*—A male, aged 26 years, was admitted after having been shot by a rifle bullet, the wound of entrance being in the left buttock and the exit wound in the right iliac fossa. His admission to hospital was probably within an hour of the injury, but his condition was poor, the skin cold and clammy, and the pulse rapid, running, and almost imperceptible. As the transverse colon was lying on the abdominal wall among the pubic hairs, the rule regarding dealing with the posterior wound first was ignored on this occasion. A continuous intravenous plasma drip was started, and operation undertaken immediately as there was considerable and persistent hæmorrhage from the wound. Wound toilet was carried out as far as possible, but as the abdominal wound was extensive and there appeared to be some loss of tissue, complete excision was not attempted.

The injuries found were as follows:—

1. Multiple perforations of the small intestine, and two extensively lacerated areas of small bowel. Six perforations were sutured, and 8 in. of bowel, including the lacerated areas, were resected, and an end-to-end anastomosis performed.

2. An intraperitoneal perforation of the bladder. The fundus was extremely lacerated, the injury being represented by a gap of 2½ in. long by 1 in. wide. This wound was repaired by a double row of sutures after excision, great care being taken with the serous coat; owing to loss of tissue, it was difficult to keep the suture line sufficiently far away from the pubis.

3. Compound fracture of the right side of the pubis. Several completely detached pieces of bone were removed.

The wound was closed leaving a drainage tube leading down into the rectovesical pouch. The operation was completed by excision of the posterior wound, and by the insertion of a large-sized catheter into the urethra. Several pints of plasma and blood were given by the intravenous drip method during and after the operation. For several days intravenous

5 per cent glucose-saline was administered and a fluid intake-output chart was recorded. A course of M & B 693 was administered. Features of a stormy convalescence were:—

1. Repeated aspiration of the stomach and other measures to deal with a moderate degree of *ileus*.

2. Infection of the wound and fat necrosis of the subcutaneous tissues, necessitating the removal of skin sutures.

3. The development of a suprapubic fistula. This was drained by means of a gauze wick drain in a Paul's soft rubber tube.

4. Suprapubic discharge of pus, i.e., the condition described by Mathé (1940). A radiograph a month after admission revealed "some decalcification of the pubic bones on both sides adjacent to symphysis pubis. Pubis fractured, with superimposed sepsis—uniting". No sequestrum developed from first to last.

5. The development of an ammoniacal cystitis, responding rapidly to irrigation with dilute acetic acid solution.

6. The wound eventually involved a wide area several inches in diameter and was covered by healthy granulations. A Thiersch graft was successfully applied with about 80 per cent 'take'.

7. Right-sided epididymo-orchitis, subsiding without pus formation.

8. A subacute attack of intestinal obstruction responded to the administration of prosthigmine and glycerin enemata. A radiograph four months after the initial injury was reported as follows: "Stomach shows normal appearance and empties normally. Deformity of cæcum (probably due to operation). No evidence of any obstruction of the small and large bowel."

After a prolonged period the suprapubic fistula closed. Normal micturition was resumed, and the patient was discharged cured several months after the injury.

*Case 2.*—A female, aged 53 years, who was brought into hospital with the history of being 'beaten up' when inebriated. Pain, tenderness, and muscular resistance were present in the hypogastric region, and there was marked tenderness in the pouch of Douglas on rectal examination. It was suggested that the patient had passed some blood in the urine. There was no evidence of fracture of the pelvis, and although the pulse-rate was 100, the temperature was normal. There was also tenderness in the right loin. The patient was taken to the theatre and cystoscopy was performed with the patient in a modified Fowler position. No more than 3 oz. of lotion were injected into the bladder, as after 2 oz. slight pain was experienced. The urine contained a fair amount of blood. Both ureteric orifices were seen and both emitted a clear efflux of urine. On the left side, near the fundus, and posterior to the air bubble, there was an irregularly bruised area largely concealed by a mass of adherent blood-clot. An intraperitoneal rupture of the bladder was diagnosed and operation carried out forthwith. A midline infra-umbilical incision was made, and the peritoneal cavity was opened and found to contain a small quantity of urine. There was a vertical slit-like intraperitoneal rupture of the bladder, the rupture being situated to the left of the midline posterior to the fundus. The rupture was about 1 in. in length and appeared to be temporarily occluded by blood-clot. The rupture was repaired by a double row of sutures, and especial care was taken with the peritoneal coat. The rest of the abdominal contents were

uninjured. A drainage tube was inserted into the pouch of Douglas and brought out of the lower end of the wound, which was then closed. A large catheter was inserted into the bladder via the urethra.

Convalescence was uneventful, and healing was obtained without the development of a suprapubic fistula.

*Case 3.*—A male, aged 27, was admitted with a small wound of the buttock. There was no exit wound. His general condition was excellent, and as a great many serious air-raid casualties had been admitted the same night apparently little was done for him initially apart from cleaning and dressing the wound, combined with the usual injection of anti-tetanic serum. He was seen by the writer for the first time two days later, as by then an indwelling catheter had been inserted on account of severe dysuria. The urine did not contain blood. A radiograph revealed a metallic fragment in the pelvis and the buttock wound appeared unhealthy, exuding a few drops of thin fluid suggestive of urine. I explored the wound, which led down to a fracture of the lateral border of the sacrum. It appeared likely that the base of the bladder had been injured, but in view of the favourable course no more was done on that occasion apart from packing the wound with an acriflavine pack and providing free drainage. During the next few days his general condition remained *in statu quo*, and urine drained via the catheter without difficulty, but a tender swelling gradually developed on the left side of the suprapubic region. Several days after the original operation a suprapubic incision was made, evacuating thick creamy pus from the pouch of Retzius. The abscess cavity led down to the left side of the base of the bladder, but no foreign body could be felt. The bladder was not opened, and the wound was closed with a large drainage tube into the abscess cavity. When cystoscopy was performed previous to the drainage operation, 5 oz. of lotion were injected into the bladder without discomfort; while the right side of the bladder was normal, there was much ecchymosis and œdema of the left side near the base. No definite opening could be seen, but a deeper shadow in the centre of the ecchymosed area suggested this. The foreign body was not in the cavity of the bladder. Following the operation, progress was satisfactory and the suprapubic wound healed without the development of a urinary fistula. Cystoscopy four weeks later revealed bullous œdema around the injured bladder base, and there was still congestion of the left side of the bladder wall.

When seen recently this man was carrying out heavy work and was symptomless. In this case, cystoscopy not only was necessary for diagnostic reasons, but also excluded the presence of a foreign body in the bladder, which did not require suprapubic drainage at any stage.

*Case 4.*—A female, aged 30 years, was punched in the lower part of the abdomen. Two hours previously the bladder had been emptied. Some abdominal pain was experienced, so she retired to bed. Several hours later the patient awoke, and on attempting to pass water, experienced severe abdominal pain and collapsed. On examination at hospital, there was lower abdominal tenderness and rigidity, and a little blood-stained urine was evacuated through a catheter. The blood was dark in colour, and did not appear fresh. There was a mild degree of shock present. An intraperitoneal rupture of the bladder was diagnosed,

and the patient taken to the theatre. Operation was performed eleven hours after the injury.

**CYSTOSCOPY.**—This was performed with the patient in a modified Fowler position. The cystoscope passed easily, and 9 oz. of blood-stained urine were evacuated. On injection of 2 oz. of sterile lotion pain was felt in the suprapubic region, so no more was injected. On inspection, a bruised area was seen just behind the fundus, and in the centre of this was a dark cleft, probably representing the rupture. A significant feature was the absence of the air bubble.

**OPERATION.**—A midline infra-umbilical incision was made, and the peritoneal cavity opened. There was some urine in the pelvis, but no peritonitis had developed. There was an intraperitoneal rupture little over 1 in. in length, running from a point on the postero-superior aspect to the highest part of the bladder. The rupture was sutured and the urine mopped out of the pelvis. The peritoneal cavity was closed, leaving a drainage tube leading down into the pouch of Douglas, and a large Malecot catheter inserted through the urethra into the bladder.

A course of sulphathiazole was administered after the operation, and the patient was nursed in the Fowler position. The wound healed well, catheter drainage being maintained for ten days. No suprapubic fistula developed, and the patient was discharged from hospital healed within three weeks of the injury.

## SUMMARY AND CONCLUSIONS

1. Injury of the bladder is not a common condition, either as a civil emergency or as a result of warfare.

2. In the majority of cases the injury of the bladder is gravely complicated by associated damage to adjacent structures.

3. An entrance or exit wound of the buttock is found in at least 75 per cent of cases. Usually through-and-through wounds are oblique in direction from the buttock to the suprapubic region or vice versa. Wounds of the buttock should, therefore, always be regarded with suspicion, especially as there may be no discharge of urine through the wound owing to the length of the track.

4. It is not always essential to drain the bladder by the suprapubic route; a large indwelling catheter may be sufficient, especially in the female.

5. It would appear that cystoscopy has a diagnostic value in this condition, and, indeed, is the only precise means of confirming certain types of injury.

6. Possibly the future will show that the prognosis, as a result of modern methods of resuscitation, combined with chemotherapy, is not as gloomy as it has been considered in the past.

## REFERENCES

- BAILEY, H. (1940), *Emergency Surgery*, 4th ed., 393. Bristol: John Wright.
- BARNES and STEELE (1935), *J. Amer. med. Ass.*, **105**, 1758.
- CAHILL, G. F. (1937), *Amer. J. Surg.*, **36**, 653.
- CHISHOLM, A. E., and FERGUSON, R. L. (1939), *Brit. med. J.*, **2**, 647.
- CODY, W. E. J. (1939), *Iowa med. Soc.*, **29**, 549.
- CROSBIE, A. H. (1924), *J. Urol.*, **12**, 431.
- FENWICK, E. H. (1886), *Trans. path. Soc. Lond.*, **3**, No. 7, 303.
- FENWICK, P. C. (1910), *Brit. med. J.*, **1**, 798.
- FULLERTON, A. (1918), *Brit. J. Surg.*, **6**, 24.
- HINMAN, F. (1935), *Principles and Practice of Urology*, 914. London and Philadelphia: W. B. Saunders.
- KEEN, M. R., and GOLDSCHLAGER, A. L. (1938), *N.Y. St. J. Med.*, **38**, 1.
- LARREY (1829), *Clin. chir.*, **2**, 501.
- LEGUEU, F., and GOUVENEUR, R. (1919), *Arch. Clin. Necker*.
- MCALPINE, J. B. (1940), "Wounds of the Bladder", *Surgery of Modern Warfare* (ed. Bailey), **2**, 247. Edinburgh: E. & S. Livingstone.
- MARQUARDT, C. R., and COOK, H. E. (1940), *Wis. med. J.*, **39**, 18.
- MATHE, C. P. (1940), *J. Urol.*, **43**, 543.
- NELIGAN (1941), *Proc. R. Soc. Med.*, **34**, No. 9, 565.
- OEHLCKER, F. (1912), *Dtsch. med. Wschr.*, **38**, 2302.
- SHIPLEY, A. M., and HAMRICK, J. C. (1938), *Amer. J. Surg.*, **42**, 542.
- STEVENS, A. R., and DALZELL, W. R. (1937), *J. Urol.*, **38**, 475.
- STIRLING, W. C. (1936), *Urol. cutan. Rev.*, **40**, 163.
- TANTON, J. (1918), *Arch. Med. Pharm. milit.*, **69**, 10.
- WALLACE, SIR CUTHBERT (1917), *Brit. J. Surg.*, **4**, 730.

## INTRAPERITONEAL CHEMOTHERAPY

By R. H. GARDINER

SURGEON TO THE ROYAL BUCKINGHAMSHIRE HOSPITAL, AYLESBURY, ETC.

PERITONITIS has long been dreaded by surgeons as a complication of the diseases of the gastrointestinal tract and of operative procedures in which opening the peritoneal cavity is a necessity. It is most commonly caused by a bacterial flooding of the cavity, due to perforation of some hollow viscus secondary to a disease of that viscus, and the resulting bacterial flora of the

infection is therefore extremely various and often multiple in its types. Far more rarely a peritonitis results from a blood-borne infection or from a direct spread upwards by way of the female genital tract. This variety of the disease (known as primary peritonitis) is far more lethal than the secondary type and responds far less readily to any form of treatment.

For the past two or three years sulphonamide drugs have been used in the prevention and treatment of peritonitis and have been the subject of much animal experiment, especially in America. Sulphanilamide was used first by direct implantation, followed by sulphathiazole, sulphadiazine, and mixtures of these. I have practically confined my attention to sulphapyridine (M & B 693), and it is my belief that this drug possesses advantages over other sulphonamides for intraperitoneal use, but it is impossible to be dogmatic when the number of cases suitable for such treatment are limited in one man's experience. There have been few published results of intraperitoneal chemotherapy in England, beyond the excellent papers of Vaughan Hudson and his collaborators (1941 and 1942).

The bacteria most commonly responsible for 'secondary' peritonitis are the normal inhabitants of the gastro-intestinal tract—*B. coli*, various strains of streptococci, *Cl. welchii*, and *B. proteus*. *B. pyocyaneus* is a common secondary invader. *B. coli* will often outgrow other bacteria. Streptococci sometimes cause a severe peritonitis in a perforative lesion of a hollow viscus, and also produce an extremely lethal type of primary infection. Anaerobes such as *Cl. welchii* are commonly found in the peritoneal exudates after bowel rupture, but are usually swamped by the pyogenic organisms. Many cases of appendicitis with free peritoneal fluid give either a pure culture of *B. coli* or a mixed growth, usually of *B. coli* and non-haemolytic streptococci. Mixed infections do not respond nearly so readily to sulphonamide therapy as pure ones, but owing to the non-specificity of the drugs they exercise a bacteriostatic effect of some degree on most of the bacteria occurring in a mixed infection, and herein lies one of the great advantages of this method of treatment. In primary peritonitis the usual organisms are pneumococci, streptococci, and gonococci, the pneumococci accounting for about half the cases.

It is now known that individual members of the sulphonamide group do not have a specific action on any given organism, but that organisms can be arranged in order of susceptibility to the sulphonamide group, and the sulphonamides can be arranged in order of bacteriostatic potency. It follows that an infection due to one of the less susceptible organisms, such as the staphylococcus, will be unaffected by chemotherapy unless one of the most potent drugs is used—e.g., sulphathiazole. If no substances are present which inhibit the action of the sulphonamides, then the higher the concentration of the drugs the greater will be their activity. The more organisms there are present and the higher the amount of inhibiting substances, so must the concentration of the drugs present be higher. Green and Parkin (1942) found that the antagonist of the sulphonamides is an enzyme, the substrate of which is *p*-aminobenzoic acid, and it is the capacity of the sulphonamide compound to block this substance

which determines its activity. Para-aminobenzoic acid is often found in high concentrations in pus, tissue extracts, and related substances, and their presence therefore calls for a higher concentration of the chemotherapeutic drugs—a fact which is demonstrated in the local treatment of frankly purulent peritonitis, which takes far longer to clear up than the case in which little pus is present.

There is also the possibility that a sulphonamide-resistant strain of bacteria will be encountered, or that a particular strain of bacteria will become resistant in time if not quickly overcome by the drugs. Ehrlich years ago pointed out in relation to the chemotherapy of protozoal infections that a large dose should be given over a short period, to prevent resistant strains developing.

### ABSORPTION BY THE PERITONEAL LINING MEMBRANE

The rate of absorption of any substance placed in the peritoneal cavity is of extreme importance. The selected substance, if it is to be beneficial, must be present in a sufficient concentration in the immediate environment of the bacteria long enough either for the infection to be wiped out or for the normal body responses to be marshalled and obtain control. The ideal chemotherapeutic drug for local application will be one which has the lowest rate of absorption, thereby remaining in situ for the longest period, provided it is capable of dealing with the infecting agent and has no serious deleterious effects. There is no other method of obtaining so high a local concentration as by local implantation. If used locally either in the soft tissue or in the body cavities, a local concentration 75–100 times as great as systemic administration could give may be obtained directly at the source of infection (Mueller and Thompson, 1942).

Sulphanilamide is very rapidly absorbed into the blood-stream from the peritoneum; in fact faster than by any other route of administration (except direct intravenous injection), and so a very high blood concentration is rapidly obtained. Hudson and Smith (1942) found, using an average dose of 15 g., that a peak was reached in the blood-stream in about 12 hours, with a blood concentration of 7–12 mg. per 100 c.c., the figure falling to zero in 36–48 hours. They further noted that the concentration obtained in the blood-stream is very variable and that a peak reading of 20 mg. can be obtained and absorption continue up to three days, and that the presence or absence of inflammation does not appear appreciably to affect the absorption rate. Mueller and Thompson (1942) gave very similar figures, and also found very high levels in the peritoneal fluid taken at intervals after operation, the figures ranging from 300 mg. to 800 mg. per 100 c.c. after 40 hours. All published reports confirm this rapid absorption of sulphanilamide, and its use

may be criticized on the grounds that its rapid absorption does not allow the drug to remain in adequate concentration locally long enough for the full benefit of its direct action to be obtained,

the peritoneal cavity. Sulphapyridine and sulphadiazine show the longest survival rates in situ, and my observation of the absorption of sulphapyridine from the peritoneum gives further

Table I.—PROPERTIES OF FOUR SULPHONAMIDE DRUGS  
(After Lyons and Burbank)

	SULPHANILAMIDE	SULPHAPYRIDINE	SULPHATHIAZOLE	SULPHADIAZINE
Solubility in serum at 37° C.	1600 mg.	61 mg	184 mg.	124 mg.
Persistence as crystals	6-24 hr.	7-10 days	4-5 days	5-7 days
Excretion in twenty-four hours	50 per cent	7 per cent	18 per cent	?
Persistence by chemical test	11 days	34 days	17 days	?
Diffusion time in wounds	2 hr.	24 hr.	2-6 hr.	6-24 hr.
Toxicity to cells	+	0	+	0

and that toxic effects are more likely to follow its use for the same reason. Jackson and Coller doubt if its local action remains very high after 1-2 hours (cf. Throckmorton's experiments with

proof of its long persistence locally. I have been unable to find any other reports on the absorption of sulphapyridine.

The following experiments were conducted to find out the rate of absorption of sulphapyridine from the peritoneal cavity.

Table II.—BLOOD CONCENTRATIONS OF SULPHAPYRIDINE (mg. per 100 c.c.) IN FIVE OF THE CONTROL CASES AFTER INTRAPERITONEAL IMPLANTATION OF SULPHAPYRIDINE IN 4 OZ. OF SALINE

CONTROL CASE	HOURS AFTER ADMINISTRATION		
	24	48	72
I	2.5	2.0	1.7
II	3.1	2.1	1.5
III	3.2	1.6	1.2
IV	2.6	2.2	1.9
V	2.4	2.1	1.6

**Experiment 1.**—Ten control cases were taken. These were all diagnosed as chronic appendicitis, and inflammation was not a factor to be taken into account. Laparotomy by a right paramedian incision was performed, the abdominal cavity explored, and the appendix removed. Before sewing up, 10 g. of sulphapyridine suspended in 4 oz. of saline was placed in the abdominal cavity, and the drugs were lightly rubbed into the wound. Samples of blood were taken at 24, 48, and 72 hours, and 7 days after operation. Readings typical of the results obtained are shown in Table II. This table gives the readings obtained in five of the controls, showing the close similarity of the readings, which was true of all the cases. A week after operation the readings varied between 0.4 mg. and 0.7 mg. per 100 c.c.

**Experiment 2.**—Blood-levels were taken from a series of cases in which inflammation was present and

rats, in which he found no trace of the drug locally after 6-8 hours), and state that it would be ideal if some method could be devised which would slow the rapid absorption, so allowing it to remain at a high local concentration; failing that, an allied compound with a slower rate of absorption should be used. (These workers did attempt to cut down the rate of absorption of sulphanilamide by using a tragacanth suspension of the drug, but without any appreciable success.)

The absorption rate of sulphathiazole appears to lie between that of sulphanilamide and sulphapyridine, although I have been unable to find a complete series of blood-concentration figures following its intraperitoneal introduction. Lyons and Burbank (1942), in a collective review on local sulphonamide therapy, compared the properties of the various chemotherapeutic drugs, and Table I is reproduced from their paper. The table was deduced from a series of published experimental results by several workers following the implantation of the drugs into wounds and

Table III.—BLOOD CONCENTRATION OF SULPHAPYRIDINE (mg. per 100 c.c.) IN FIVE CASES OF PERITONEAL INFLAMMATION OF VARYING DEGREE AFTER INTRAPERITONEAL IMPLANTATION OF 10-15 G. OF SULPHAPYRIDINE IN 6 OZ. OF SALINE

DESCRIPTION OF CASE	HOURS AFTER ADMINISTRATION		
	24	48	72
Perforated appendix with general peritonitis Drainage	3.3	1.7	1.4
Appendicitis Appendix acutely inflamed at tip Peritoneum inflamed and raw in appendix bed	5.0	2.6	2.2
Acute appendicitis with free fluid. Drainage	2.7	2.4	1.8
Acute perforated appendicitis with general peritonitis. Death three weeks after operation from a subphrenic abscess and empyema	3.7	2.4	2.0
Pelvic abscess. Bilateral salpingo-oophorectomy for bilateral tubo-ovarian abscess Drainage of abscess	1.8	1.5	1.3

there was free fluid or pus in the peritoneal cavity. This series included cases of appendicitis with free fluid, appendicitis with general peritonitis, pelvic abscess, and perforated gastric ulcer. The dosage



in these cases was 10–15 g. suspended in 4–6 oz. saline. Allowance must be made for a slight loss through overflow of the substance during introduction, which it is not always possible to avoid, although about one-half was introduced via the drainage tubes at the end of the operation. The findings are shown in *Table III*.

Comparison of *Tables II* and *III* shows that there is little variation in absorption whether gross inflammation or pus formation is present or not, so that sulphapyridine does not differ in this respect from other drugs of the series. But the rate of absorption shows a much slower and more gradual fall, and zero was not reached even at the end of the week, readings averaging 0.5 mg. per 100 c.c. being consistently obtained whether inflammation was present or not. Large individual variations in the rate of absorption are occasionally found; readings as high as 15–17 mg. per 100 c.c. have been recorded in a case of hemicolectomy for carcinoma of the cæcum and in a case of perforated duodenal ulcer. These, however, are exceptional. Opportunities for direct observation to ascertain whether any of the drug remains after operation are rare. White granules of the drug can be seen coming out of a drainage tube from the abdomen in a few cases several days after administration, but this is not usual, and I have only noted it if gross suppuration was present at operation. One case, however, is worthy of record:—

*Case 1.*—A woman of 58 was admitted with an advanced carcinoma of the rectum, deemed just to be within the bounds of operability. She was prepared for an abdomino-perineal resection, which was subsequently performed by Mr. C. A. Joll. During the operation the extremely friable growth ruptured and the peritoneal cavity was grossly contaminated with bowel contents; 15 g. of sulphapyridine in saline was placed in the abdomen and a further 15 g. in the perineal wound. She never recovered completely from post-operative shock and developed chest complications from which she died 84 hours after operation. The abdomen was opened post mortem, through the original incision, which showed no obvious sulphapyridine. There was no free fluid or pus in the peritoneal cavity, and the sulphapyridine was in process of absorption. At a very rough guess about 25 per cent of what had been put in remained as small clumps about the size of a pin's head on the small gut and posterior wall. There were no signs of inflammation or adhesion formation.

Ryan, Bauman, and Mulholland (1942) record the blood-levels and urinary excretion of sulphadiazine following its introduction into the peritoneal cavity of six patients. In three of these, receiving 10 g. each, the figures ranged as in *Table IV*.

The peak absorption occurred between 12 and 36 hours after administration, and it will be noted that the figures, although a little higher, are similar to those which I obtained with sulphapyridine. They recorded much higher readings in two other cases using 20–25 g. of the drug. There were no apparent post-operative or toxic complications. Sulphapyridine and

sulphadiazine are, therefore, the slowest of the four common sulphonamide drugs to be absorbed from the peritoneal cavity, which is in accordance with their low solubility.

*Table IV.*—BLOOD CONCENTRATION OF SULPHADIAZINE (mg. per 100 c.c.) IN THREE PATIENTS AFTER INTRAPERITONEAL IMPLANTATION OF 10 G. OF DRUG (After Ryan, Bauman, and Mulholland, 1942)

CASE	HOURS AFTER ADMINISTRATION		
	24	48	72
I	6.0	3.7	2.5
II	5.7	4.5	1.5
III	4.7	1.6	1.1

## METHODS OF ADMINISTRATION AND DOSAGE

Sterilization of the sulphonamide powders was not generally thought necessary until the report of a case of tetanus which proved fatal seven days after operation for a suppurative condition in the pelvis of a woman. Sulphapyridine had been sprinkled into the pelvis before the closure of the abdomen. The verdict of the Coroner was death by misadventure from tetanus, due to infection from a sulphapyridine container (*Lancet*, 1942; Atkinson, 1942; Sandes, 1942). Before the report of this case I had placed the powder in the abdominal cavity, from the cardboard containers, in upwards of fifty cases. An effective technique for sterilizing sulphonamide powders has been evolved (Medical Research Council, 1943) and sterile preparations should now be exclusively used.

It is necessary to consider whether there is any other way of administering sulphonamides which is superior to the intraperitoneal route in the treatment of peritoneal infections. Cokkinis (1938) reported favourably on the oral use of sulphonamides in acute appendicitis after operation, whether contaminated or not, and especially in cases of late acute appendicitis with localized lump formation without obvious abscess development; in these the drug seemed to hasten resolution. Favourable results were also obtained in frank peritonitis, and in a case of subphrenic abscess. No actual figures were published.

Corry, Brewer, and Nicol (1939) reported the use of sulphonamides by various routes other than the peritoneal in the treatment of peritonitis of appendicular origin; they summarized 41 cases of appendicitis with varying grades of abscess formation and peritonitis, with apparently favourable results. A series of 273 cases of acute appendicitis with a mortality rate of 1.1 per cent compared favourably with a previous five-year period which showed a mortality rate of 5.3 per cent. Toxic manifestations were frequent in this series, sometimes necessitating stopping administration of the drug.

Rosenberg and Wall (1941), experimenting with artificially produced peritonitis in rats,

showed that the intraperitoneal route was definitely superior to the subcutaneous. Stafford (1942) reported 479 cases of peritonitis or abscess of appendiceal origin at the Johns Hopkins Hospital with a mortality rate of 10 per cent, but since using sulphathiazole in such cases, either by mouth or intravenously, the mortality rate had been reduced 50 per cent. Complications were few and the blood-level was kept at 6-8 mg. per 100 c.c. Hudson and Smith (1942) stated that their results, using any route other than the intraperitoneal, were disappointing. In their inquiry into the best way of controlling infection in abdominal war wounds, Gilchrist and his colleagues (1943) demonstrated in dogs that sulphanilamide by mouth will not produce adequate early concentrations in blood and peritoneal exudate.

From the patient's viewpoint, there have been far more undesirable features in these other routes of introduction, of which vomiting and prostration have been the most unpleasant. They are distressing in the extreme to a patient already ill with an abdominal disease, and seem to be avoidable by using the intraperitoneal route. Intramuscular injection may produce severe pain at the site of injection, and such catastrophes as nerve palsies must not be forgotten. The intravenous route seems to be best if the drug is to be given systemically, and it can be given via a drip saline. If the intraperitoneal and other routes are combined there seems to be a special danger of jaundice (Jackson and Coller, 1942).

Care must be observed in the application of the drugs to the peritoneal cavity. The powder may be (1) dumped in; (2) sprinkled in from a perforated container on the 'pepper-pot' principle; (3) dusted in by means of a sterile gauze swab. These may be termed the dry methods of application. Dumping and sprinkling are, however, inadvisable, for there is a great tendency for too much powder to accumulate at one spot. This, to my mind, is the most fertile cause of subsequent adhesions, particularly with the drugs which have a low rate of absorption. I have frequently noted in my earlier cases that if any large mass of the drug is allowed to fall into the peritoneal cavity in one place it is rapidly enmeshed by the peritoneum, and so firmly that only vigorous wiping will remove it, and this may result in a tearing of the bowel surface. Crutcher and his colleagues (1943) have observed in dogs that sulphonamides introduced in lump become walled off as a foreign body and are absorbed very slowly; they noted that fine powders are more liable to form lumps than coarse crystals. Dusting the powder over the bowel surface with a soft gauze swab is a useful method to employ around an anastomosis of bowel or wherever a definite local concentration of the drug is desired.

Apart from such dusting, the drugs should always be applied in a fluid suspension; a solution is not possible owing to their low solubility. The suspension is best made by rapidly stirring

the finely powdered drug in sterile saline. For 10-15 g. of the powder about 6-8 oz. of sterile saline is necessary. The powder is rapidly stirred until a thin watery emulsion is obtained. This is then at once transferred to the peritoneal cavity and is best squirted in rapidly with a 10- or 20-c.c. Record syringe, so that a jet of the emulsion is sprayed over the contents of the peritoneal cavity. The drug will then be seen to adhere to the peritoneum in small clumps over very wide areas and gross dumping of large masses will be avoided. This method makes for easier absorption, and obviates adhesion formation. The one drawback is the spilling of the emulsion over the edges of the wound, so that a quantity of the powder is lost. This is especially the case if the anaesthetic does not give good relaxation. If a spinal anaesthetic has been used, the 'negative' intra-abdominal pressure and laxity of the muscles allows the fluid to be squirted or poured in quite easily and little will escape. If introduction is difficult and drainage is to be used, some of the suspension may be injected down the tube after the complete closure of the abdomen. A spigot must be at once inserted to prevent overflow. Hudson and Smith (1942) recommend the use of an indwelling catheter, led into the cavity through the abdominal wound; the suspension can be injected down the catheter, which is then clipped off. Further quantities of the suspension can be introduced on future occasions if deemed advisable, although they say that these may cause considerable pain.

I have employed the method only once and the patient did not seem to suffer discomfort. The spigot of the drainage tube should be removed six hours after operation to allow normal drainage to begin. The dregs of the emulsion can be rubbed lightly into the separate wound layers. If pus is present, it should be removed, either by gently swabbing, or, if in great quantity, by a sucker, but it is never easy to clear out all the purulent products. It is, however, highly important to do this as far as possible, in order to remove the inhibitors of the drug, of which pus is a fertile source—a point first emphasized by Tashiro et al. (1942).

Chambers et al. (1942) have described the reduction in the size of sulphathiazole crystals by the method of sonic agitation. By this method minute crystals, uniform in size, are produced which will give a stable aqueous suspension with little tendency to settle. The micro-crystals will pass through a syringe needle. A quicker absorption is noted with these small crystals, especially during the first two hours. Clumping is easily avoided, and if such a suspension is placed in the abdominal cavity, it rapidly spreads over the intestinal surface. This type of preparation seems to possess distinct advantages for intraperitoneal use.

Solutions of the soluble forms of sulphonamides are unsuitable for intraperitoneal administration, on account of their very high alkalinity

and consequent strong caustic action. This is especially true of sodium sulphapyridine. Yet Fox (1942) has conducted experiments in mice and dogs in which the sodium salts of sulphapyridine, sulphathiazole, and sulphadiazine were introduced into the muscles and peritoneal cavity. His results showed a rapid absorption with good healing and no obvious necrosis. He suggests, therefore, that clinical trials with these solutions are warranted. Even if further experiment confirms that they are not seriously irritating, they will not supplant powder when it is essential to maintain a high concentration at one place—e.g., along a line of anastomosis. Furthermore, their absorption may be too rapid; the object of a powder is to keep a good concentration *in situ* for as long as possible.

Investigators have widely divergent views on dosage. Ryan, Bauman, and Mulholland (1942) have given up to 25 g. with no ill effects, whereas Jackson and Collier (1942) advised against doses greater than 5 g. Dosage must depend on the condition found at operation. In the absence of frank pus or gross inflammation small doses suffice, and 10 g. in 4 oz. of saline is adequate. I generally use 15 g. of sulphapyridine in 6 oz. of saline in contaminated cases, remembering that it is impossible to prevent the loss of a certain amount from spilling and overflow. If frank suppuration is present, far higher doses are required, because of the inhibitory powers of pus, and I have inserted 25 g. of sulphapyridine with no toxic results.

### COMPLICATIONS

In the cases in which I have used sulphapyridine in the abdominal cavity, the complications which might ensue, and which are often troublesome when the drug is given by mouth or injection have been entirely absent; there has never been any cause for anxiety due to development of a toxic state from the drug. The dose has usually been 15 g., and this amount has been used in the abdominal cavities of children in serious infections. I attribute the lack of toxicity to the slow absorption of sulphapyridine as compared with sulphanilamide, although sulphathiazole has been the cause in some cases. Lyons and Burbank (1942) studied the toxicity of the sulphonamides to living cells, noting the depression of cell development and the limitation of cell growth, and concluded that sulphanilamide is more toxic than other chemotherapeutic drugs, on account of its higher solubility. This was also true of its action in the suppression of the red and white blood-corpuscles, whereas subsequent toxic effects were not observed with sulphapyridine or sulphadiazine.

#### General Complications.—

**Blueness.**—One thing which will always strike the surgeon after the introduction of the drugs into the peritoneal cavity is the blue colour of the skin. This appears to have little significance, as the blueness rapidly disappears, although it is

often more marked than with oral administration while it lasts. Hudson and Smith (1941 and 1942) remarked on this blue coloration, but they had observed no serious toxic symptoms with sulphanilamide.

**Depression and Restlessness.**—No patient of mine has complained of the extreme depression commonly encountered after oral administration, and I have seen no published reports of this as a complication of intraperitoneal administration. At times after relatively large doses in young children I have noted extreme restlessness and what appears to be disorientation comparable to that seen after oral administration; but these children have all been suffering from a severe illness, and it is difficult to know to which cause one should attribute such signs.

**Vomiting.**—Beyond that which can readily be attributed to a post-anæsthetic complication, vomiting never occurs with intraperitoneal sulphapyridine, and I have not seen it reported with the other drugs used. This is extremely important, and, as Pearl and Rickles (1942) pointed out, oral administration is not desirable and is often impossible in a patient very ill with an abdominal complaint because of vomiting.

**Jaundice.**—Reports from America stress the possible occurrence of severe jaundice. Sulphanilamide placed in the peritoneal cavity is probably absorbed by the portal system and carried to the liver in high concentration; this may account for the jaundice, which is not seen if the drugs are used in peripheral wounds, where it will be absorbed into the caval system (Lyons and Burbank, 1942). Jackson and Collier (1942), experimenting with dogs, showed that if sulphanilamide was used intraperitoneally there was always a higher concentration of the drug in the portal blood than in the systemic. They also recorded a number of cases in which definite jaundice developed—9 out of 29 patients so treated—if the sulphanilamide was administered by other routes as well as the intraperitoneal, and the jaundice was due to hepatic damage. The jaundice seemed to clear without permanent results, but because of it they advise only modest intraperitoneal doses. Watson and Spink (1940) believe that a mild liver damage, secondary to toxic drainage from intraperitoneal sepsis via the portal vein, can be converted into outspoken hepatic dysfunction and jaundice if the toxic effects of the sulphonamide drugs are superadded.

Bieter et al. (1941) show in children that with sulphanilamide, even if given orally, there is a selective concentration in the liver, as compared with sulphapyridine and sulphathiazole. Davis (1942) also points out that sulphanilamide should not be used if there is any suspicion of liver damage, as it may make the damage considerably worse, and also states that 6 g. is the highest safe intraperitoneal dose if such a complication is to be avoided. Hudson and Smith reported no cases of jaundice with sulphanilamide or sulphathiazole, and I have never encountered a case

with sulphapyridine even from massive doses in severely toxic patients.

*Traperitoneal chemotherapy.*—This must be a very rare event. I have never seen it in my own cases, and I have only read of one possible case elsewhere (Lesses and Starr, 1942).

*Renal Complications.*—There has not yet, as far as I know, been any case of anuria recorded as a complication of intraperitoneal chemotherapy, but since several fatal cases of anuria, and some successfully treated, have followed the use of sulphapyridine by mouth, some mention must be made of it here.

*Case 2.*—I recently operated on a child for appendix abscess (which would have been better treated on expectant lines), and as free pus was liberated I followed my usual routine and placed 10 g. of sulphapyridine into the peritoneal cavity. The child's urine was passed normally for three days after operation, but he passed only 1 oz. from 9 a.m. on the third day until 2 a.m. next morning, when he passed 12 oz. From 2 a.m. until 8.15 p.m. on this fourth day he passed no urine, but at the end of that time he passed 10 oz. It was scanty on the fifth day, and he passed 8 oz. on the evening of the sixth day. This gave cause for anxiety, but from the seventh day his urine output rapidly became normal and a clean specimen examined showed only occasional red blood-corpuscles.

I have also seen hæmaturia result from the prolonged application of sulphapyridine to large raw areas following burns in children. It is therefore important to watch for this serious complication, carefully to control the dosage in a child, and to see that adequate fluids are given by mouth in all cases, supplemented by rectal administration in children if necessary (a far better method in children than via the veins).

#### Local Complications.—

*Inflammation, Adhesions, and Non-absorption.*—When any substance is injected into the peritoneal cavity a reaction occurs which results in peritonitis, variable in degree. The nature, amount, and type of substance introduced will naturally determine the type and severity of the reaction (Harvey, Meleney, and Rennie, 1942). Any chemotherapeutic drug will thus cause a reaction in the peritoneum; but if the reaction helps to marshal the body's defences against a serious infection it will assist in overcoming such infection. If, however, it is too severe or too prolonged, adhesions may be left behind.

The possibility of the formation of adhesions has received a great deal of attention in the literature, ranging from a deprecation of the use of sulphonamides in the peritoneal cavity altogether on account of the danger of such adhesions and other evils (Taylor, 1942), through a warning that adhesions may occur, to a frank denial that adhesion formation is of much importance. Jackson and Collier (1942) found that there was little reaction on the part of the peritoneum in dogs when sulphanilamide was introduced, as evidenced by hyperæmia or adhesion formation, and also believe that scarring may actually be

prevented by its introduction. Autopsies on two of their patients who had been treated by such methods showed little peritoneal reaction with very few adhesions. Laird and Stavern (1942) examined the peritoneal reaction in dogs, using sulphanilamide and sulphathiazole. They found that these drugs produced no reaction or adhesions and there was no trace of the drug four weeks after introduction. The sodium salt of sulphathiazole, however, produced pronounced adhesion formation and inflammation, due to its high alkalinity (pH about 10). The alkalinity of the soluble form of these drugs definitely precludes their use in the peritoneal cavity, and the only sodium salt which can be used in solution is sulphacetamide soluble, which is neutral, but a solution has no advantages over a powder.

Laufman and Wilson (1942) showed that sulphanilamide was relatively non-irritant to the peritoneum of rats, and this has been confirmed in the same animal by Throckmorton (1941), using both sulphanilamide and sulphathiazole. He further reported that sulphapyridine had a marked irritant action, leaving many adhesions and large quantities of the drug walled off. Hawking and Hunt (1942) reported that sulphadiazine placed in the peritoneum of dogs remained cut off and walled off by adhesions. Walter and Cole (1943) observed some adhesions in dogs after the intraperitoneal insertion of sulphadiazine, but these were never dense; there were no adhesions after sulphanilamide. Crutcher and his colleagues (1943) found that sulphanilamide, sulphathiazole, and sulphadiazine may all produce adhesions if they are not well spread about; sulphanilamide was least liable and sulphadiazine most liable to produce adhesions. Sutton (1942) reports the case of a boy who was operated on for acute gangrenous appendicitis and peritonitis and in whom the intraperitoneal use of sulphathiazole was followed by adhesions and intestinal obstruction, necessitating a second operation about three months afterwards, when dense adhesions were found in the right iliac fossa. The cause of the obstruction—the crystals of sulphathiazole—had disappeared. He also stated that there was delayed wound healing and a keloid scar. Only 3 g. was sprinkled into the peritoneal cavity and the area was drained.

There has been no reference to the reactions produced by sulphapyridine except that Throckmorton has stated that it was highly irritant to the rat peritoneum, producing well-marked adhesions, and that particles of the drug were left behind. Though I have nearly always used the drug in my own cases I have encountered adhesion formation in two cases only (reported below), and in neither could the use of the sulphapyridine be blamed as the cause. The following case suggests that sulphapyridine does not tend to produce adhesions or to remain in situ for an undue time.

*Case 3.*—A woman aged 41, was operated on in 1941 for acute appendicitis and early peritonitis (Gardiner, 1942). She made an uninterrupted

recovery except for a slight left basal pneumonia. The peritoneal cavity was drained through the lower end of the incision, which was a right paramedian. She was re-admitted one year later complaining of a slight hernia through the lower end of the scar where the drainage tube had been inserted. An operation for repair was performed, the old scar excised, the wound layers defined by dissection, and the peritoneal cavity opened. There were no signs of the sulphapyridine, or of any adhesions except some purely local ones around the great omentum and the back of the abdominal scar, and a very few filmy ones in the right inguinal fossa, round the cæcum. These were separated with great ease and a repair carried out.

In *Case 1*, the abdomino-perineal resection for advanced carcinoma of the rectum in which the growth ruptured, the sulphapyridine four days after operation was in the process of absorption and only minute clumps remained.

I have recently been able to confirm the absence of gross adhesion formation in further cases following the use of sulphapyridine in peritonitis. One case, an old man of 75, who was operated on for advanced general peritonitis, following a ruptured appendix, died three weeks after. He developed paralytic ileus five days after the operation, from which he never recovered in spite of treatment. There were but few adhesions found post mortem. His abdominal wound (a right paramedian incision) healed firmly.

The following two cases were complicated by adhesion formation following operation:—

*Case 4.*—H. M., aged 7 years, was admitted to hospital on Nov. 29, 1943, with a history of 24 hours' abdominal pain and vomiting. Pulse 116; respiration 24; temperature 103°. Chest and urinary system normal. He had marked generalized abdominal pain and tenderness. A diagnosis of appendicitis with peritonitis was made and operation was performed the same evening. Through a right paramedian incision a high cæcum was mobilized with difficulty, due to gross inflammation and free pus. A gangrenous retrocaecal appendix was removed with difficulty. Sulphapyridine (15 g.) was instilled into the abdominal cavity and the wound powdered. The abdomen was drained. His progress for the first five post-operative days was good, and his bowels were well opened with enemata on the third and fourth days. After this, however, he was not so well, and on the seventh day he began to show signs of obstruction, with onset of distension. He began to vomit on the eighth day and on the ninth radiography revealed distended coils of gut with fluid levels, with obstruction probably at the ileocaecal valve. His abdomen was opened through the original incision and the terminal coils of ileum were found bound together with loose adhesions. Inflammation was gross. The adhesions were separated easily and the obstruction relieved. Three clumps of sulphapyridine the size of large beads were found adhering to the bowel wall firmly; the rest was practically absorbed. They were not removed. The abdomen was closed and the child made an uninterrupted recovery except for a breakdown of the superficial layers of the abdominal wound which took some time to heal up.

*Case 5.*—J. McC., aged 51 years, was admitted to hospital on June 2, 1943, with a history that he had been suffering from abdominal pain and upset for one week. This had begun previously as a severe central abdominal pain which subsided but had come on again with extreme violence and he had been vomiting. On examination he was an extremely sick-looking man with a hard, blown-out, distended abdomen. His temperature and pulse were normal. As it was a definite case of an abdominal catastrophe, operation was performed the same night and he was found to be suffering from very advanced general peritonitis due to a perforated inflamed Meckel's diverticulum. The whole of the abdomen was full of small-gut contents with severe inflammation and pus formation. The diverticulum was removed and the abdomen drained by two large tubes. Sulphapyridine (25 g.) was injected into the abdominal cavity. Following this operation he appeared to make a good recovery and for the first ten days following the operation went on very well, his appetite, bowel actions, etc., returning. About the tenth post-operative day, however, he began to show signs of an obstruction and in the ensuing eight hours this became much more marked and was confirmed by radiographs, which showed fluid levels. His abdomen became distended and he began to vomit violently. He was seen by Mr. C. A. Joll in consultation, who advised an immediate further laparotomy, which was performed on June 16. On opening the abdominal cavity, practically the whole of the small intestine was found matted up together with a vast number of thin filmy adhesions, and there was a high obstruction. Efforts were made to free these adhesions without success. Residual amounts of the sulphapyridine were found lying between the coils of gut and also in the pelvis. He did not recover from this operation, but died on June 18.

The type of adhesions which were seen in this case were exactly similar to those which I have found in cases of strangulated hernia which have been described by other writers and they are, in my opinion, almost exclusively confined to cases in which the peritoneal cavity has been grossly contaminated with small-gut contents. I do not think it is true to say that the contents of the small gut do not cause gross peritoneal inflammation or subsequent adhesion formation, as it has always been in these cases that I have found a widespread plastic peritoneal reaction, and I think, further, that the peritoneum of some individuals is more prone to irritation by small-gut contents than are others. I do not think that the sulphapyridine in these cases was the cause of the adhesions.

It appears that slight adhesion formation will occur whatever the drug used, and in certain individuals who have a natural tendency to form adhesions. All surgeons know that, after operations for inflammatory and other abdominal conditions, dense adhesions do form in a few cases, and this will happen whatever form of intraperitoneal chemotherapy is employed. The risk is undoubtedly outweighed by the advantages to be gained from these drugs; it will not be great if, as far as possible, an even distribution is obtained, and the dumping of a mass of powder in any one area is avoided.

*Delayed Healing.*—There has been much controversy on this aspect of chemotherapy. Bick (1942) concluded that the local application of sulphonamides to wounds of soft tissue at a clean operation, in which primary suture was indicated, reduced the rate of healing by 5 per cent, and also caused extensive cutaneous scarring. The scars also seemed to be greater in depth and breadth. Taylor (1942) placed sulphathiazole, sulphanilamide, and sulphadiazine beneath the rectus sheath in dogs, and found that sulphathiazole and sulphadiazine caused actual abscess formation, and there was inflammation with sulphanilamide. Apart from these two papers and the isolated case of Sutton (1942) already mentioned, most reports speak well of the effect of the drugs on wound healing and in the prevention of suppuration and subsequent breaking down of the wound. Key and Burford (1941) report from animal experiment that there is no interference with the healing of the soft tissues if sulphanilamide is implanted, provided certain precautions are observed. They now implant the powder as a routine in all wounds. The powder should be lightly sprinkled in the wound and too much should be avoided, as this tends to cause serum outpouring. They found that by using the powder as a routine, the incidence of stitch abscess was less and that all wounds, in a series of 150 cases, healed by first intention. Davis (1942) and Mueller and Thompson (1942) state that sulphonamides stimulate healing.

In a previous communication (1942) I drew attention to the excellent healing obtained in contaminated wounds following laparotomy for peritonitis or a 'dirty' appendix if sulphapyridine was employed. Similar cases have further convinced me of the efficacy of the drug in preventing breakdown and suppuration of the wound, with their attendant evils, such as prolonged stay in hospital while the wound granulates, burst abdomen, wound phagedæna, and subsequent herniation through the scar. In the past eighteen months I have ceased to drain any contaminated wound, but have gently rubbed a fine emulsion of powdered sulphapyridine in saline into the wound layers, prior to closure by primary suture. In not one of the cases, although often freely contaminated, has a breakdown occurred. Most of them healed by first intention, and in a few a little purulent fluid escaped which subsequently dried up with sound wound healing. Nor does there seem to be any acceleration in the absorption of the catgut (Adeney, 1941). Drainage tubes have often been employed in cases of gross contamination of the peritoneal cavity, but the hole for the tube alone has remained open for drainage of the pus, the rest of the wound healing soundly. In one case an incisional hernia occurred, but this was through a drainage tube hole, used to drain the pelvis in pelvic appendicitis. It should not be necessary to apply the sulphonamide in a surgically clean wound, but if used properly in such cases it should do no harm. I

have not observed any excessive keloid formation after the use of the drugs.

## RESULTS IN ACUTE ABDOMINAL CONDITIONS

**1. Appendicitis.**—The largest number of reports of intraperitoneal chemotherapy have the treatment of acute appendicitis and its complications as their basis. In the short time in which it has been in use this procedure has done much to lower the mortality in complicated appendicitis. Thus, Hudson and Smith (1942) showed a fall in mortality in cases of peritonitis and peritoneal contamination from 18.4 to 6.4 per cent. From 1935 to 1939, 741 cases of acute suppurative appendicitis were treated at the Roosevelt Hospital in New York with 20 deaths, a mortality rate of 2.7 per cent; in 1940, 204 such cases were operated on, but these also received intraperitoneal sulphanilamide therapy and there were no deaths. Thompson, Brabson, and Walker (1941) reported its use in 59 cases of acute diffuse appendicitis with favourable results, some of the cases appearing to be hopeless. Anderson (1942) reported 22 cases of advanced acute appendicitis treated by operation and intraperitoneal sulphathiazole (5 cases also received additional sulphathiazole either intravenously or orally) with one death, a mortality rate of 4.5 per cent. Pearl and Rickles (1942) produced a pure *B. coli* peritonitis in rats and found that sulphathiazole afforded complete protection if the drug was given at the time of introduction of the bacteria; in diffuse peritonitis one rat died, whereas all the control cases ended fatally. Epps, Ley, and Howard (1942) experimented with dogs in which a perforating appendicitis was produced, and sulphanilamide, sulphapyridine, and sulphathiazole were placed in the peritoneal cavity at intervals in the course of the illness; sulphathiazole gave the lowest mortality rate.

I have used sulphapyridine in all stages of acute appendicitis over the past two and a half years and the results have been gratifying. Seemingly hopeless cases of general peritonitis have made a rapid recovery, and many less advanced cases have done extremely well. Exudate was either reduced to a thin serous yellow discharge which did not last long, or if purulent did not continue for anything like the time it did before I used sulphapyridine. There have been three deaths, two reported above, and another in an advanced case of general peritonitis in which the whole abdomen was full of pus, and a pelvic abscess developed which cleared satisfactorily, but a right posterior subphrenic abscess formed subsequently, and I unfortunately delayed drainage too long. I still feel that drainage should be instituted in all cases where there is any doubt in the surgeon's mind. Nothing is to be lost by drainage, and, if frankly purulent discharge does not develop, the tube can be removed within 24–48 hours. It must not be assumed from the published results that a purulent discharge will



never occur; but if drainage has been employed the surgeon can feel safe. Wound healing has been remarkable in cases receiving intraperitoneal sulphapyridine in the presence of the grossest contamination; whatever the type of incision, healing by first intention has nearly always occurred. One or two obese patients have had superficial abscesses which have drained for a few days, but there has never been a major breakdown of the wound and the final healing has been gratifying. In grossly contaminated cases which have been drained by a large tube let into the pelvis, healing has been just as sound and a clean granulating hole left when the tube has been withdrawn. I never drain the individual wound layers as in the past. This means that both immediate complications, such as wound phagedæna, and remote ones, such as ventral hernia, should become increasingly rare.

Finally, the time spent in hospital is immensely reduced, some cases of general peritonitis leaving after ten days only. In the past it has not been unusual for such a case to remain in for weeks, with a persistent purulent discharge.

It must not be assumed that chemotherapy is the complete panacea for peritonitis after appendicitis. Two facts interfere with the results—a mixed infection, and the presence of much free pus, usually due to a widespread peritonitis of some days' duration. If a pure culture is obtained at operation, for example *B. coli* alone, the results of treatment are good; but if a mixed culture is obtained, for example, *B. coli* and *Str. fecalis*, healing is much slower. A large quantity of pus inhibits the action of the drugs, and in such cases the method loses a good deal of its efficacy. Possibly some chemotherapeutic compound will be discovered which will not be so inhibited, or the drug will be combined with an efficient neutralizer of those inhibitors. At present we can only use the drug in increased doses in such cases and clear the cavity of as much pus as possible at operation.

**2. Perforated Peptic Ulcer.**—I have employed chemotherapy in only two cases of perforated peptic ulcer, and of these one had been perforated for 28 hours and the other for 22 hours before operation. The first patient died the day after operation, but the second made an excellent recovery. My other cases have all been operated on within 12 hours of perforation, and I did not employ chemotherapy because these early cases do well without. Griswold and Antonic (1941) treated 111 cases of perforated peptic ulcer with intraperitoneal sulphanilamide, with 20 deaths. Wakeley (1944) advocates its use in these cases.

**3. Perforated Diverticulitis.**—In my series there have been three cases, two previously reported (Gardiner, 1942), and a third in which, in addition to the use of chemotherapy, I exteriorized the loop of the sigmoid colon involved, owing to the extent of the perforation, and the patient died. The two other cases were successful, and no colostomy was performed in either.

**4. Intestinal Obstruction.**—Hudson, Smith, and Selbie (1941) give figures of the high mortality rate still found in acute intestinal obstruction. The two commonest causes of obstruction were strangulated hernia and carcinoma of the colon. They pointed out that the cause of the high mortality rate, especially in small-gut obstruction, was late diagnosis with a consequent late institution of treatment, and that the prognosis was bad if resection of bowel had to be performed instead of simple release. Where simple release alone was practised, the mortality rate was 5.2 per cent, but if a resection was required, it was 77.4 per cent. This very high fatality rate in cases requiring resection was ascribed to peritonitis developing owing to the escape of the gut contents and contamination at the actual operation. Experiments with rabbits showed that intraperitoneal sulphanilamide prevented the development of peritonitis when the cavity had been contaminated with the cæcal contents, and that it reduced the inflammation following resection of the gut. There is little doubt that the mortality rate would be much reduced if the risk of the plastic peritonitis found in these cases some days or weeks after operation could be abolished. They reported three cases of strangulated hernia requiring resection of gangrenous gut, with subsequent recovery (loc. cit., Hudson and Smith, 1942), and I have had two such cases. Of my two, one, previously reported, died, but the other recovered from operation.

**Case 6.**—An elderly man operated on for a strangulated right femoral hernia. The gut was found to be non-viable; about 1½ ft. was resected and an end-to-end anastomosis performed. The line of anastomosis was carefully powdered with sulphapyridine, the gut replaced in the abdominal cavity, a catheter fed into the cavity through the dilated neck of the hernial sac, and 20 g. of powdered sulphapyridine in saline squirted in. A Lothieson type of repair was then performed, the whole operation being completed from below. In spite of his poor general condition (he was recovering from influenza and bronchitis), the man made an uninterrupted recovery.

It is to be hoped that surgeons will try out similar treatment with other cases.

**5. Pelvic Abscess.**—I have treated two acute cases of this condition, the cause in both being pyosalpinx and tubo-ovarian abscess. A radical operation was carried out in both, all the diseased tissue being removed and the pelvis drained. Both made an excellent recovery, with far less discharge than is usual, and sound healing. The third case, operated on by Mr. V. J. F. Lack, was a chronic suppurative condition of the pelvis, due to bilateral tubo-ovarian abscesses. Twice before the patient had had simple drainage of a pelvic abscess performed. All the diseased tissue was removed, the pelvis was filled with an emulsion of 15 g. of sulphapyridine in saline, and the pelvis drained. The wound was liberally treated with sulphapyridine powder. She drained for approximately three weeks, but the wound, a left

paramedian incision, healed soundly by first intention, whereas after the two previous operations she was left with a large right ventral hernia.

**6. Miscellaneous.**—I have used sulphapyridine in isolated cases of other acute abdominal emergencies and operations resulting in contamination—for example, empyema of the gall-bladder, drainage of the common bile-ducts, intussusception, internal obstruction of the small gut due to adhesions and in one case to a phytobezoar necessitating opening of the ileum for its removal (Gardiner, 1943), all with good results. It is evident, therefore, that there is a wide scope for intraperitoneal chemotherapy in the surgery of the acute abdomen, both as a prophylactic and curative measure. Brief reports of typical cases with the results obtained, etc., are presented in *Table V*.

### PRIMARY PERITONITIS

I have had only two cases of primary peritonitis, both due to the pneumococcus :—

**Case 7.**—A girl aged 8 years, admitted with a history of 6 days' illness, ushered in with diarrhoea and vomiting, followed by abdominal pain. She was extremely toxic and ill on admission, temperature  $102^{\circ}\text{F}$ ., pulse 116, with a tender distended abdomen, generalized guarding, and pain and tenderness in the right inguinal fossa. A diagnosis of general peritonitis from a perforated appendix was made. She was operated on at once and a gridiron incision was used, but on opening the abdomen thick greenish-yellow pus poured out, a good deal of it in the form of flakes. There was generalized inflammation of the whole of the peritoneal contents, but the appendix, apart from the general reddening, was normal. A primary pneumococcal peritonitis was diagnosed and culture later showed pneumococcus, Type I. The appendix was removed, a suprapubic stab drain inserted, and a fine soft rubber catheter placed in the abdominal cavity and brought out of the gridiron incision before closure; 15 g. of sulphapyridine in saline was instilled into the cavity at the end of the operation. Subsequent blood examination showed a sulphapyridine level within the usual limits. The course of the illness after operation was not satisfactory. On the fifth day the suprapubic tube was removed and the catheter slowly withdrawn. Thick greenish-yellow pus continued to be discharged, and the temperature remained at  $100^{\circ}$ – $101^{\circ}\text{F}$ . during the first ten days, rising to  $103^{\circ}\text{F}$ . on the eleventh day, when a further 5 g. of sulphapyridine in saline was instilled into the abdominal cavity via the catheter. This caused no pain or discomfort. The dose was repeated on the fourteenth day, but there was no change in the temperature or in the amount of discharge. A course of sulphapyridine by mouth was started on the eighteenth day and a slight drop in temperature was noted, but a blood-count revealed a total leucocyte-count of 2000 per c.mm. only, with 6 per cent polymorphs, and the drug was at once discontinued. The red-cell count was 3,400,000 per c.mm. The chest then came under suspicion. There was some dullness at the left base, and a radiograph revealed a small effusion at the left base, with some collapse of the left lower lobe. The fluid aspirated from the chest was sterile. The midline stab drain still continued to exude a small amount of yellow pus, but there were no signs of a residual

abscess intraperitoneally or in the pelvis. The child's general condition was now good, with fair appetite. The temperature finally settled, and the flow of pus from the abdominal cavity gradually dried up, and she was discharged cured.

In this case I cannot claim that the intraperitoneal sulphapyridine had any dramatic effect. Possibly the fact that the child had been ill for six days and that there was so much pus nullified its full effect.

**Case 8.**—A girl, aged 5 years, was admitted to hospital on April 12, 1943, with a history of four days' abdominal pain, vomiting of black fluid, and profuse green stools. On examination, she was a pale, poorly nourished, very sick child, with dry furred tongue, dirty mouth, and somewhat tumid abdomen. Temperature  $102.6^{\circ}$ , pulse 130. There were no other physical signs. A tentative diagnosis of enteric fever or dysentery was made. The following investigations were made :—

Blood : W.B.C. 9000 (79 per cent polymorphs).  
Hæmoglobin (Haldane) 84 per cent = 11.5 g. per cent  
Stools : No abnormal organisms detected on three occasions.  
Urine : N.A.D.  
Blood-agglutination tests : All negative.  
Blood-culture : Negative.

A course of sulphaguanidine was at once given, and by April 18 the temperature had settled and the pulse fallen, but both rose again on April 22 when the course was completed. On April 28 abdominal paracentesis was done, and a turbulent fluid obtained, which, on culture, gave a pure growth of pneumococcus Type 1, thus giving the diagnosis. Following this a course of sulphamethazine was given, but it had little effect as the temperature and pulse still remained elevated and it was discontinued on May 6. A further course was started on May 11 and, following this second course, the temperature gradually settled and did not rise after May 18. The child was discharged cured to a convalescent home.

Points of importance in this case : (1) Difficulty of diagnosing cases of primary pneumococcal peritonitis; (2) Value of abdominal paracentesis and bacteriological examination from fluid obtained; (3) The disease seems to 'run its course' in spite of the sulphonamide drugs—in this case sulphamethazine was given a trial, but it did not seem to shorten the course of the illness.

It would appear from the published reports that in both the pneumococcal and the streptococcal types of primary peritonitis it is better to treat on expectant lines rather than to operate, provided the diagnosis is not in question. Aspiration of the peritoneal fluid and its microscopical examination will throw light on the diagnosis, and an emulsion of sulphapyridine could be injected into the peritoneal cavity by a needle and syringe. If the diagnosis is confirmed, parental or other means of administration, possibly combined with introduction into the peritoneal cavity, will be the best method of treatment in such cases, reserving operation for the opening of residual abscesses, should any form.

### CHEMOTHERAPY IN LARGE-BOWEL SURGERY

It has been pointed out that intraperitoneal chemotherapy is far more successful in mild or moderate contaminations which might lead to



Table V.—DETAILS OF RESULTS OF CHEMOTHERAPY WITH SULPHONAMIDES IN ACUTE ABDOMINAL CONDITIONS

CASE	AGE AND SEX	DISEASE	OPERATION	DRUG USED IN 3-6 OZ. SALINE	RESULT	WOUND HEALING	LENGTH OF STAY IN HOSPITAL
1	36, M.	Acute retrocaecal appendicitis with free pus	Appendicectomy by gridiron incision	5 g. sulphapyridine	Uninterrupted recovery	First intention	8 days
2	16, M.	Appendicitis—two days' duration	Very inflamed appendix removed via gridiron incision. Free fluid present. Drainage	10 g. sulphapyridine	Uninterrupted recovery	First intention	12 days
3	44, F.	Appendicitis—three days' duration	Appendicectomy retrocaecal, tip inflamed. Free fluid	10 g. sulphapyridine	Uninterrupted recovery except for post-operative bronchitis	First intention	13 days
4	4, F.	Appendicitis—twelve hours' duration	Appendicectomy by paramedian incision	5 g. sulphapyridine	Uninterrupted recovery	First intention	12 days
5	46, M.	Acute on chronic appendicitis. Acute for twenty-four hours	Appendicectomy—right paramedian incision. Very inflamed necrotic appendix removed. Drainage	10 g. sulphapyridine	Uninterrupted recovery	First intention	11 days
6	8, F.	Acute appendicitis with peritonitis—few hours' duration	Appendicectomy—right paramedian incision. Perforated pelvic appendix removed. Two drains inserted	10 g. sulphapyridine	Uninterrupted recovery	First intention	20 days
7	68, F.	Abdominal pain twenty-four hours' duration. Acute appendicitis	Right lower paramedian incision. Very inflamed and swollen appendix, with inflamed coils of gut. Appendix removed. Drainage	10 g. sulphapyridine	Uninterrupted recovery	First intention	17 days
8	49, F.	Abdominal pain thirty hours. Appendicitis	Right lower paramedian incision. Gangrenous appendix removed. Large quantity free pus in peritoneal cavity. Drained by stab wound in right iliac fossa	15 g. sulphapyridine	Uninterrupted recovery	First intention	22 days; retained 8 extra days due to poor home conditions
9	17, M.	Three weeks' history, abdominal pain, diarrhoea, and vomiting varying in intensity. Diagnosed as appendicitis	Gridiron incision. Very inflamed appendix removed. Free fluid	15 g. sulphapyridine	Uninterrupted recovery	First intention	14 days
10	7, M.	Acute on chronic appendicitis	Right paramedian incision. Inflamed appendix. Meckel's diverticulum removed	5 g. sulphapyridine	Uninterrupted recovery	First intention	15 days
11	44, F.	Appendicitis with peritonitis	Right paramedian incision. Appendix removed. Two drains	10 g. sulphapyridine	Uninterrupted recovery, except for slight post-operative chest	Uninterrupted, except for small incisional hernia at lower end of paramedian incision due to drainage tube	15 days
12	70, M.	Strangulated right femoral hernia of (?) several hours' duration. Also acute bronchitis	Hernia freed. 1½ ft. gangrenous gut resected. End-to-end anastomosis	20 g. sulphapyridine	Uninterrupted recovery	First intention	17 days
13	4, M.	Acute appendicitis, with general peritonitis	Right paramedian incision. Appendix removed. Two drains in peritoneal cavity	20 g. sulphapyridine	Uninterrupted recovery	First intention	13 days

# INTRAPERITONEAL CHEMOTHERAPY

Case No.	Age & Sex	History	Operation	Chemotherapy	Recovery	Remarks
15	20, F	Admitted as primipara in labour. Thirty-six hours after delivery, sudden onset of acute peritonitis with peritonitis	Large quantity free pus in peritoneal cavity. Volvulus of ascending colon, and half transverse colon found. Right hemicolectomy performed	15 g sulphapyridine	Uninterrupted recovery	First intention 16 days
16	15, F.	Very acute appendix	Operation by gridiron incision. Retrocaecal appendix, perforated, removed. General peritonitis, with large amount of free pus. Drainage	15 g sulphapyridine	Uninterrupted recovery	First intention 14 days
17	4½, M	Several attacks abdominal pain and vomiting	Right paramedian incision. Slight amount free fluid in peritoneal cavity. Appendix removed	10 g sulphapyridine	Uninterrupted recovery	First intention 11 days
18	39, M	Two days' abdominal pain. Diagnosis—appendicitis	Right paramedian incision. Retrocaecal appendix abscess found and drained. Large amount of pus	10 g sulphapyridine	Uninterrupted recovery	First intention 16 days
19	75, F	Admitted as acute appendicitis with early peritonitis	Gridiron incision. Gangrenous retrocaecal appendix removed. Free pus present. Drainage	10 g. sulphapyridine	Uninterrupted recovery	First intention 17 days
20	60, M.	Acute on chronic obstruction due to carcinoma of hepatic flexure	Right paramedian incision. Gangrenous appendix, with early general peritonitis. Appendix wound in right iliac fossa	10 g. sulphapyridine	Uninterrupted recovery	First intention Up 16 days after operation, but retained for further 10 days due to home conditions
21	46, F.	Acute appendicitis, with early peritonitis	First operation. Ileotransverse operation. Fourteen days later, right hemicolectomy; leakage operation. Drainage	10 g. sulphapyridine	Uninterrupted recovery	Discharged 23 days after second operation
22	43, F.	Appendicitis—eight hours	Right paramedian incision. Gangrenous appendix with free pus wound in right flank	10 g sulphapyridine	Uninterrupted recovery	14 days
23	18, F.	One weeks' history abdominal pain, vomiting, and diarrhoea outside hospital. Patient very ill—diagnosed as general peritonitis	Right paramedian incision. Inflamed, perforated appendix removed. Drainage.	10 g. sulphapyridine	Uninterrupted recovery	10 days
24	29, M.	Three-day history abdominal pain and vomiting. Appendicitis	Right paramedian incision. Huge quantity of free pus evacuated. General peritonitis. Perforated appendix removed. As much pus evacuated as possible and lower end of incision	25 g sulphapyridine	Stormy convalescence, but eventual good recovery except for long drainage over many weeks	Several weeks
25	22, F	Forty-eight hours' abdominal pain and vomiting. Diagnosed as appendicitis and peritonitis	Right paramedian incision. Acutely inflamed appendix removed with free pus. Stab drain in flank	10 g. sulphapyridine	Uninterrupted recovery	14 days
26	22, F	Twenty-six hours' history abdominal pain and vomiting. Acute appendicitis	Right lower paramedian incision. Pus and free fluid present. Difficult pelvic appendix removed. Stab drain in right flank	20 g. sulphamylamide	Uninterrupted recovery	26 days
			Gridiron incision. Free fluid present. Very inflamed appendix removed. No drainage	5 g sulphamylamide	Uninterrupted recovery	12 days

Table V.—DETAILS OF RESULTS OF CHEMOTHERAPY WITH SULPHONAMIDES IN ACUTE ABDOMINAL CONDITIONS, continued

CASE	AGE AND SEX	DISEASE	OPERATION	DRUG USED IN 3-5 OZ. SALINE	RESULT	WOUND HEALING	LENGTH OF STAY IN HOSPITAL
27	76, F.	Five days' history strangulated femoral hernia	Under local anesthetic. Strangulation revealed: 1 ft. gangrenous gut removed. End-to-end anastomosis	25 g. sulphapyridine and sulphathiazole mixture	Stormy period following operation and death six days after. Post mortem, no peritonitis or evidence of sulphonamides left. Anastomosis intact. Death due to heart failure and bilateral pneumonia	—	—
28	54, M.	Extensive carcinoma of stomach, with pyloric obstruction. Impossible to clear stomach by washouts	Partial gastrectomy. Foul smelly contents poured into peritoneal cavity at operation	20 g. sulphanilamide	Stormy convalescence, but subsequent recovery	First intention	25 days
29	17, F.	Three days' abdominal pain. Acute appendicitis	Right paramedian incision. Slightly inflamed appendix and McEckel's diverticulum removed. No drainage	10 g. sulphapyridine	Uninterrupted recovery	First intention	16 days
30	32, M.	Seven days' history abdominal pain, vomiting, etc. Diagnosed as appendicitis	Right paramedian incision. Some free fluid. Appendix removed. Stab drainage	10 g. sulphanilamide	Uninterrupted recovery	First intention	26 days
31	61, F.	Thirty hours' abdominal pain, vomiting, etc. Signs of general peritonitis	Right paramedian incision. Cavity full of free pus. Perforated appendix removed. Stab drain in flank	20 g. sulphapyridine	Uninterrupted recovery	First intention	17 days
32	7, M.	Two days' history abdominal pain	Right paramedian incision. Perforated appendix removed. Free pus in peritoneal cavity. Drainage right flank	15 g. sulphapyridine	Slow convalescence. Eventual uninterrupted recovery	First intention	22 days
33	15, M.	Two days' history abdominal pain and sickness. Diagnosis—appendicitis	Right paramedian incision. Free pus on opening abdomen. Perforated appendix removed. Stab drain right flank, also drain through lower end of abdominal wound	15 g. sulphanilamide	Stormy convalescence. Signs of pelvic abscess formation sixteen days after operation. Pelvic abscess drained seventeenth day via rectum	First intention	3 weeks after second operation
34	32, F.	History of two days' abdominal pain and vomiting. Diagnosis of appendicitis	Appendix removed through grid-iron incision. Very inflamed	10 g. sulphanilamide	Uninterrupted recovery	First intention	12 days
35	11, F.	Fifty hours' history of abdominal pain and vomiting. Diagnosed as appendicitis	Right lower paramedian incision. Very inflamed appendix removed with free pus. Stab drain inserted	10 g. sulphanilamide	Uninterrupted recovery	First intention	16 days
36	11, M.	Twenty-four hours' history of abdominal pain and vomiting. Appendicitis	Right lower paramedian incision. Very inflamed and swollen appendix removed, which was perforated accidentally in course of operation, with escape of free pus into peritoneum. Stab drain in right iliac fossa	10 g. sulphanilamide	Interrupted by persistent temperature	First intention	36 days
37	16, F.	Four days' abdominal pain, vomiting, etc. Appendicitis	Right paramedian incision. Very inflamed appendix removed. Some free fluid. Stab drain in right iliac fossa	10 g. sulphanilamide	Convalescence interrupted by wound infection and probable peritonitis. Subsequent recovery	Subsequent healing poor. Breakdown of lower part of main wound. Had to be reopened and drained	36 days

# INTRAPERITONEAL CHEMOTHERAPY

No.	Age, Sex	History	Operation	Medication	Remarks	Days
38	I.	Long history of attacks of abdominal pain, menorrhagia. Suddenly became acute. Diagnosed as pelvic abscess due to salpingitis	Right iliac fossa. Very large abscess. Both tubes removed. Large drain into pelvis	10 g. sulphathiazole	Uninterrupted recovery	16 days
39	M.	Twenty-four hours' abdominal pain and vomiting. Diagnosed as obstruction	Laparotomy—right paramedian incision. Bilateral tubo-ovarian abscesses found. Both tubes removed. Large drain into pelvis	20 g. sulphathiazole into pelvis	Uninterrupted recovery	25 days
40	M.	Admitted for investigation of rectal bleeding. At sigmoidoscopy pelvic colon accidentally perforated	Right paramedian incision. Diagnosis confirmed. Terminal appendix being obstructed by long appendix very inflamed. Appendix removed. Obstruction relieved	10 g. sulphathiazole in peritoneum	Uninterrupted recovery	23 days
41	F.	History of forty hours' general abdominal pain, also in right iliac fossa. Abdomen distended	Immediate laparotomy. Perforation found and sutured and contents of large bowel cleared from pelvis. Drainage of pelvis	10 g. sulphathiazole	Uninterrupted recovery. Bleeding found to be due to piles	40 days
42	F.	Three days' abdominal pain in lower abdomen. Diagnosed as appendicitis? pelvic abscess or salpingitis	Right lower paramedian incision. Appendix normal. Gall-bladder found to be gangrenous and full of pus. Incision extended. Gall-bladder removed. Drainage right flank	25 g. sulphapyridine in abdominal cavity	Although patient very ill, she made a good recovery except for persistent temperature which was due to persistence of drainage. This subsequently dried up	20 days
43	F.	Twenty hours' abdominal pain, vomiting. Obese lady. Pain on deep pressure in both iliac fossae. Diagnosed as retro-caecal appendicitis	Right lower paramedian incision. Burst appendix, with abscess found. Appendix and adherent omentum removed. Large stab drain	16 g. sulphapyridine	Uninterrupted recovery	41 days
44	M.	Four days' abdominal pain. Diagnosed as acute appendicitis	Gridiron incision. Extremely inflamed ruptured appendix removed with difficulty. Free pus drained	10 g. sulphapyridine	First intention	17 days
45	M.	Three days' abdominal pain. Diagnosed as acute appendicitis	Gridiron incision. Very inflamed gangrenous appendix with free pus found. Appendix removed, cavity. Abdomen drained	10 g. sulphapyridine	Slight discharge from wound, but subsequent recovery	Up 10 days after operation, but retained in hospital 21 days owing to Naval routine
46	F.	Thirty-six hours' abdominal pain, vomiting, etc. Very rigid abdomen. Diagnosed as peritonitis	Right paramedian incision. Perforated appendix, with peritonitis. Drainage in right flank	15 g. sulphapyridine	First intention	Up tenth day, but retained 22 days owing to Naval routine
47	F.	Six days' abdominal pain. Two days' vomiting, diarrhoea. Abdomen distended and tender all over. Diagnosed as appendicitis with peritonitis	Right lower paramedian incision. Extreme amount of free pus and inflamed bowel. Appendix removed and abdomen drained	25 g. sulphapyridine	First intention	11 days
					Good, except for persistent temperature, for which no apparent cause could be found except peritoneal inflammation. This gradually settled	32 days

grave trouble than in gross contamination with pus already present. In the surgery of the large bowel, the problem of how to overcome or prevent the onset of gross infection in cases of accidental or unavoidable contamination—for example, in resection of the colon for cancer, with an anastomosis of the cut ends—has not been solved. In the resection of any portion of the alimentary tract from stomach to rectum a subsequent anastomosis may leak and cause peritonitis, and any method which will help to prevent this will be useful. Varco et al. (1941) pointed out that it was difficult to prevent leakage in internal anastomosis in dogs, a 25 per cent leakage rate occurred, and there was a 20 per cent mortality rate from this cause in the Mann-Williamson operation. When in their experiments they placed crystalline sulphanilamide in powder form around the suture lines at the time of operation, the mortality rate from leakage and peritonitis fell to nil; 37 such successful operations were performed, a total of 6 g. only of the powder being placed around the anastomotic line. Autopsy showed all suture lines well sealed with fibrin and the rest of the peritoneum in a normal state.

Garlock and Seley (1939) state that peritonitis is the chief cause of death, and remark on the greater safety of multiple-stage procedures. Methods of producing peritoneal immunity using sera, vaccines, amniotic fluid, etc., have all been unsuccessful. At the time of operation on colon cancers they made cultures of pericolic tissue, bowel wall, and mucosal surfaces, and found that the predominant organisms were hæmolytic streptococci and *B. coli*; 21 cases were treated pre-operatively with sulphanilamide by mouth, and at subsequent operation it was found that the hæmolytic streptococci were absent and that subsequent soiling of the peritoneum at operation did not produce so serious results, and healing was exceedingly good.

It appears that in intraperitoneal chemotherapy we have a safeguard against peritonitis from leakages at suture lines, provided that the operation is performed in the complete absence of obstruction (which all surgeons agree should receive primary relief by some form of decompression operation), and that due regard is given to a careful method of suture in performing the anastomosis. Careful powdering of the anastomosis with sulphapyridine and the instillation of a suspension of the drug into the peritoneal cavity appear to obviate infection should leakage occur. All the inevitable minor contaminations will be controlled likewise, although it is doubtful if such minor contamination is of serious import. Varco et al. (1941) advocated primary resection and anastomosis in cases of colonic cancer, using sulphapyridine by mouth prophylactically.

Wilensky (1942) records several cases of accidental peritoneal contamination with the contents of the large bowel or small gut during resection with no evil effects after the use of intraperitoneal sulphanilamide. I record here

three personal cases all requiring resection of the large bowel, in which gross faecal contamination occurred, which will illustrate the action of sulphapyridine in preventing subsequent peritonitis. *Case 1* also illustrated this action.

*Case 9.*—A woman, aged 43, was admitted on Oct. 30, 1942, diagnosed as large-bowel obstruction due to intussusception. The illness started four days previously with general abdominal pain, marked diarrhoea and colic, with extremely frequent bowel actions and discharge of mucus. The symptoms became worse the day before admission and a large quantity of blood was passed. Apparently the illness began as an acute gastro-enteritis, prevalent in her home district at the time. Her general condition was good, there was no vomiting, no dehydration, and the blood-pressure was 120/90 mm. Hg. The abdomen was distended, especially over the descending colon, where a big mass was felt. There was also a mass which could be felt per rectum about 3 in. from the anus, and blood and mucus were escaping. The same night the abdomen was opened through a right paramedian incision and an enormously long engorged pelvic colon presented, with blackened gangrenous outer coats and some free fluid. The descending and upper parts of the pelvic colon had intussuscepted into the lower parts of the pelvic colon. The mesentery was extremely oedematous. At the pelvicorectal junction, as soon as it was handled, the mesentery split away. An effort was made to reduce it, but the outer bowel coats immediately split for almost their whole length in the long axis, which enabled reduction to be attained. This left about 3½ ft. of torn gangrenous large bowel, mostly sigmoid colon, ending at the upper end of the rectum. A rapid resection of the gangrenous bowel was done and a modified Hartmann operation performed. The upper end of the rectum was closed and the lower end of the descending colon brought out into the left inguinal fossa as a permanent colostomy; 15 g. of sulphapyridine in saline was placed in the cavity and the wound lightly powdered. The patient stood the operation well and made an uninterrupted recovery, being discharged convalescent one month after operation.

*Case 10.*—A man, aged 54, admitted with intestinal obstruction due to a string cancer of the sigmoid. This was relieved by a preliminary cæcostomy. A second operation for resection of the growth was performed three weeks later, the growth and an ample portion of healthy bowel on either side being resected and an end-to-end anastomosis being performed by Mr. Joll. Peritoneal contamination occurred at operation and the suture lines were carefully powdered and 15 g. of sulphapyridine was placed in the peritoneal cavity. The patient made an uninterrupted recovery.

*Case 11.*—A woman, aged 48, was operated on by Mr. Joll in April, 1941, when a Hartmann operation for removal of cancer of the pelvicorectal junction was done, followed by an excellent recovery. As there were no signs of recurrence fifteen months afterwards, it was decided to do a reconstitution of bowel continuity. At this operation, also performed by Mr. Joll, the colon was brought down and telescoped through the opened-out rectal stump on the Hochenegg principle, and the colon stitched all round to the rectal stump; 15 g. of sulphapyridine was placed in the cavity and the junction carefully powdered. The junction was drained through the old colostomy opening. An uninterrupted recovery was made with excellent results.

The method has also been employed in two primary resections of the right side of the colon for cancer of the cæcum and ascending colon. The above are representative cases, and we are now using the method in all cases of resection of the large bowel.

### SUMMARY

1. No method of effectively combating peritonitis by a direct attack had been devised before the introduction of the sulphonamide drugs, which are successful in a large majority of cases if used intraperitoneally.

2. Diversity of bacterial flora and the presence of a large quantity of free pus interfere with the action of the sulphonamides in peritonitis.

3. Sulphapyridine and sulphasulphapyridine appear to be the drugs of choice, and sulphasulphapyridine shows the slowest absorption rate and the lowest toxicity of any so far employed.

4. On an average 15 g. is the dose of the sterilized powder recommended, but 25 g. or more may be inserted if profuse suppuration is present.

5. Contaminated wounds treated with an emulsion of the sulphonamide powders will heal by first intention in the large majority of cases.

6. Intraperitoneal chemotherapy should now be included in the armamentarium of all emergency surgeons. This is borne out by the reports showing a fall in the mortality rate of appendicitis and its complications and other acute abdominal conditions when it is employed.

7. Encouraging results appear to accrue from its use in intestinal obstruction necessitating bowel resection, but further investigation is necessary.

8. The whole course of large-bowel surgery may be altered by the use of intraperitoneal chemotherapy, and axial anastomosis become a safe method and that of choice in reconstituting bowel continuity.

9. Care in diagnosis, pre- and post-operative treatment, and technique are essential, and chemotherapy is but an adjunct to these.

I wish to thank Mr. C. A. Joll for advice on the surgery of colonic cancer and for permission to publish some of his cases; Mr. V. J. F. Lack for his co-operation in the cases of pelvic peritonitis in women; Prof. J. McIntosh, for his advice and criticism on the bacteriology and the influence of chemotherapeutic drugs on bacteria; the house surgeons and sisters of the Royal Buckinghamshire Hospital and Tindal House Emergency Hospital, Aylesbury, for their assistance with the management and investigation of cases; and Messrs. May & Baker for the sulphasulphapyridine used in this investigation.

### REFERENCES

ADENEY, N. F. (1941), *Brit. med. J.*, 2, 824.

ATKINSON, E. C. (1942), *Ibid.*, 2, 24.

BICK, E. M. (1942), *J. Amer. med. Ass.*, 118, 511.

VOL. XXXII—NO. 125

BIETER, R. N., et al. (1941), *Ibid.*, 116, 2231.

CHAMBERS, L. A., et al. (1942), *Ibid.*, 119, 324.

COKKINIS, A. J. (1938), *Brit. med. J.*, 2, 901.

CORRY, D. C., BREWER, A. C., and NICOL, C. (1939), *Ibid.*, 2, 561.

CRUTCHER, R. R., DAVID, R. A., and BILLINGS, F. I. (1943), *Amer. Surg.*, 117, 677.

DAVIS, M. B. (1942), *Southern Surg.*, 99.

EPES, C. H., LEY, E. B., and HOWARD, R. M. (1942), *Surg. Gynec. Obstet.*, 74, 176.

FOX, C. L. (1942), *Arch. Surg., Chicago*, 45, 754.

GARDINER, R. H. (1942), *Lancet*, 1, 95.

— (1943), *Brit. med. J.*, 1, 81.

GARLOCK, J. H., and SELEY, G. P. (1939), *Surgery*, 5, 787.

GILCHRIST, R. K., STRAUS, F. H., HANSELMAN, R., DRAA, C. C., LAWTON, S. E., and FREELAND, M. (1943), *Surg. Gynec. Obstet.*, 76, 689.

GREEN, H. N., and PARKIN, T. (1942), *Lancet*, 2, 205.

GRISWOLD, R. A., and ANTONCIC, R. F. (1941), *Ann. Surg.*, 113, 791.

HARVEY, H. D., MELENEY, F. L., and RENNIE, J. W. R. (1942), *Surgery*, 2, 244.

HAWKING, F., and HUNT, A. H. (1942), *Brit. med. J.*, 2, 604.

HUDSON, R. VAUGHAN, and SMITH, R. (1942), *Lancet*, 1, 437.

— — — and SELBIE, F. R. (1941), *Ibid.*, 1, 438.

JACKSON, H. C., and COLLIER, F. A. (1942), *J. Amer. med. Ass.*, 118, 194.

KEY, J. A., and BURFORD, T. H. (1941), *Surg. Gynec. Obstet.*, 73, 324.

LAIRD, G. J., and STAVERN, H. (1942), *Calif. West. Med.*, 293.

LADD, W. E., BOTSFORD, T. W., and CURNEN, E. C. (1939), *J. Amer. med. Ass.*, 113, 1455.

*Lancet* (1942), 2, 194.

LAUFMAN, H., and WILSON, C. E. (1942), *Arch. Surg., Chicago*, 44, 55.

LESSES, M. F., and STARR, A. (1942), *New Engl. J. Med.*, 226, 558.

LYONS, C., and BURBANK, C. (1942), *Surg. Gynec. Obstet.*, 74, *Int. Abstr. Surg.*, 571.

MEDICAL RESEARCH COUNCIL (1943), *Medical Use of the Sulphonamides*. London.

MUELLER, R. S., and THOMPSON, J. E. (1942), *J. Amer. med. Ass.*, 118, 189.

PEARL, M. J., and RICKLES, J. A. (1942), *West J. Surg. Obstet. Gynec.*, 50, Feb.

ROSENBERG, S., and WALL, N. H. (1941), *Surg. Gynec. Obstet.*, 72, 568.

RYAN, J. D., BAUMAN, E., and MULHOLLAND, J. H. (1942), *J. Amer. med. Ass.*, 119, 484.

SANDES, G. M. (1942), *Brit. med. J.*, 2, 80.

SCHMIDT, E. K. (1941), *Surgery*, 9, 871.

STAFFORD, E. S. (1942), *Surg. Gynec. Obstet.*, 74, 368.

SUTTON, H. B. (1942), *J. Amer. med. Ass.*, 119, 559.

TASHIRO, K., PRATT, O. B., KOBAYASHI, N., and KAWAICHI, G. K. (1942), *Surgery*, 2, 671.

TAYLOR, F. W. (1942), *J. Amer. med. Ass.*, 118, 959.

THOMPSON, J. E., BRABSON, J. A., and WALKER, J. M. (1942), *Ibid.*, 118, 189.

THROCKMORTON, T. D. (1941), *Proc. Mayo Clin.*, 16, 423.

VARCO, R. L., HAY, L. J., and STEVENS, B. (1941), *Surgery*, 9, 863.

WAKELEY, CECIL P. G. (1944), *Lancet*, 1, 11.

WALKER, LEROY, and COLE, W. H. (1943), *Surg. Gynec. Obstet.*, 76, 524.

WATSON, C. J., and SPINK, W. W. (1940), *Arch. intern. Med.*, 65, 828.

WILENSKY, A. O. (1942), *Med. Rec.*, 115, 61.

## SHOCK: A CONSIDERATION OF ITS NATURE AND TREATMENT\*

By J. E. DUNPHY, MAJOR, M.C. A.U.S.

PERIPHERAL vascular collapse due to a reduction of the effective blood-volume may occur in several ways from a great variety of causes. For this reason the subject of shock is particularly complex, and has been rendered more so by a vast amount of ingeniously devised experimental work which supports this or that theory of its nature. A flood of research, stimulated by the outbreak of the present war, has complicated the subject still further. This paper is presented as a résumé of both old and new facts upon which treatment and further research is being based in this Unit.

It is of interest that although the study of traumatic shock received its first great impetus during the last war, one of the most accurate and far-seeing inquiries into the nature of the problem appeared in the first volume of the *BRITISH JOURNAL OF SURGERY* in 1913. In that paper, A. Rendle Short, of Bristol, England, pointed out the inadequacies of the current theories, showed that these were not in accord with observed facts, and, largely by tempering the experimental studies of others with sound clinical observations, formulated a comprehensive conception of shock far in advance of its time. Attention is called to this important but seldom quoted paper, because now, as then, much error will be avoided if clinical observations and results are made the principal criteria by which all advances in this field are judged.

### DEFINITION AND CLASSIFICATION OF SHOCK

The mechanisms of shock are so complex and so variable that precise definition is difficult. Harkins (1941) describes the condition as "a progressive vasoconstrictive oligemic anoxia". This is a concise and excellent definition for a certain stage of shock, but it excludes the neurogenic phases. Similarly, the definition proposed by Moon (1938) "a circulatory deficiency characterized by decreased cardiac output, decreased blood-volume, and by increased concentration of the blood", eliminates hæmorrhage from the syndrome. Because of these difficulties it has been suggested that shock be described in clinical terms as a state manifested by ashen-grey pallor, a weak, rapid, thready pulse, shallow respirations, and a low blood-pressure. But, like the Hippocratic facies in peritonitis, these are late and unfavourable signs. Shock should be anticipated, recognized, and treated before it becomes so

severe. A definition is needed broad enough to include the earliest manifestations, yet sufficiently precise to exclude many conditions which are now loosely referred to as 'shock'. An international committee could clarify this problem by establishing a generally acceptable definition and classification.

#### CLASSIFICATION OF SHOCK

##### NEUROGENIC SHOCK:

Primary shock; Nervous shock; Syncope.

##### VASOGENIC SHOCK:

Histamine shock; Toxic shock.

##### HÆMATOGENIC SHOCK:

Traumatic shock; Secondary shock; Surgical shock; Oligemic shock.

##### DECOMPENSATED SHOCK:

Late shock; Advanced shock.

Shock can be defined simply as "a state of actual or impending peripheral circulatory failure due to a reduction of the effective blood-volume which is not primarily cardiac in origin". This definition is essentially the same as that advanced some years ago by Cannon (1923), and later by Blalock (1934). The insertion of the phrase, "not primarily cardiac in origin" excludes the cardiogenic type of shock described by Blalock (1940). This seems an advantage, since Stead and Ebert (1942) have shown that the clinical appearance of shock which sometimes develops in cardiac patients is the result of a decreased cardiac output due to heart failure, and not to a decreased venous return to the heart. Because such cases present entirely different problems in therapy, the term 'shock' should be restricted to conditions in which the decreased cardiac output is due to a diminished venous return.

The effective blood-volume may be reduced actually by a loss of fluid from the circulation, or relatively by an uncompensated increase in the size of the vascular system. The vascular system may increase in size because of vasodilatation, neurogenic in origin, or as a result of direct injuries to arterioles or capillaries. Accordingly the shock syndrome may be divided arbitrarily into three main groups: *neurogenic*, caused by widespread vasodilatation without primary capillary injury; *vasogenic*, arising from direct injury to the walls of the capillaries; and *hæmatogenic*, the result of a primary loss of fluid from the circulation (Blalock, 1940).

**Neurogenic Shock.**—Neurogenic shock was formerly referred to as primary shock. A high spinal anaesthesia produces this state. The paralysis of sympathetic tone, both arterial and capillary, which ensues, causes a redistribution of

\* From the Surgical Service of the Fifth General Hospital, A.P.O. 519, E.T.O.U.S.A.

blood with pooling in the lower half of the body, a fall in arterial pressure, and temporary collapse. There is no capillary injury and no loss of fluid from the circulation. As the anaesthesia wears off a normal circulatory state is restored. The exact mechanisms which produce neurogenic shock are not known, but are thought to be similar to those which result in fainting, and are probably as variable. Psychic influences, extreme fright, and pain are of importance, although their roles are little understood.

There is no evidence that neurogenic factors alone result in advanced shock. When death occurs on a neurogenic basis it is probably caused by reflex vagal inhibition of the heart, and should not be considered as shock. In theory, a prolonged loss of vasoconstrictor tone can result in the following sequence of events: a fall in arterial pressure, a lowered venous return to the heart, a decrease in cardiac output, and finally a stagnant anoxia with capillary injury, loss of fluid from the circulation through damaged capillaries, and actual reduction of the blood-volume. Phemister (1942) has produced this syndrome experimentally by prolonged stimulation of the carotid sinus.

Clinically, neurogenic shock is manifested by pallor, sweating, and hypotension. Although the patient may appear seriously ill, the pulse is slow and fairly full rather than rapid or thready, and the extremities seem less cold than in advanced hæmatogenic shock. Recovery is usually prompt unless there are associated vasogenic or hæmatogenic factors. Although rare as a cause of death, neurogenic complications are of importance in other forms of shock (Ebert et al., 1941; McMichael, 1942; Wallace and Sharpey-Schafer, 1941).

**Vasogenic Shock.**—The classical example of vasogenic shock is histamine intoxication. When histamine in appropriate doses is injected into an experimental animal, the principal effect is direct injury to the capillaries, as a result of which constrictor tone is lost and arterial pressure falls. Subsequently, as the venous return to the heart diminishes, the cardiac output is reduced. In addition, there is, to a certain extent, a loss of fluid from the circulation through the damaged capillaries, a slowly progressive hæmoconcentration, and finally an actual reduction of the blood-volume, with stagnant anoxia, further capillary injury, and death. The actual reduction of the blood-volume is not marked. It occurs comparatively late and the fluid is lost into previously normal tissues throughout the body rather than into a local area of injury.

Although vasogenic shock is fairly well exemplified by histamine intoxication in the experimental animal, the exact clinical conditions belonging in this category are not clear. Various forms of shock, in which 'toxæmia' is thought to play a role, such as the later stages of severe burns, certain forms of drug poisoning, the peripheral circulatory failure which sometimes accompanies severe infections, and anaphylactic

shock, are all loosely placed in this category. Thus, at the present time there are included many types of collapse, the exact nature of which is not known, but in which primary capillary injury can reasonably be thought to play the dominant role.

**Hæmatogenic Shock.**—Hæmatogenic shock is the result of an actual loss of fluid from the circulation. This may occur as plasma in burns or crushing injuries, as blood in hæmorrhage, or as water and electrolytes in severe vomiting, diarrhoea, or high fever. Although there are many important differences among these types, a factor common to all is an immediate reduction of the blood-volume. This is followed by two compensatory phenomena: the movement of available extracellular tissue fluid into the bloodstream, and vasoconstriction. The former attempts to restore the blood-volume, but since red blood-cells and proteins are not as readily available as fluid, hæmodilution occurs. The latter maintains the arterial pressure despite the reduced blood-volume and a diminishing venous return and cardiac output. This compensatory vasoconstriction, though beneficial in maintaining an adequate circulation to vital centres, may lead to tissue anoxia and capillary injury in the areas deprived of blood by the vasoconstriction (Freeman, 1935). As the blood-volume is further reduced the arterial pressure falls, despite continued vasoconstriction, and a stage of stagnant anoxia with generalized capillary and tissue injury supervenes. Finally, as a consequence of the capillary and tissue injury, fluid may be lost from the circulation, not only at the site of injury but throughout the viscera.

This sequence of events represents in the simplest terms the course of hæmatogenic shock, regardless of cause. Actually, the problem is not this simple because of certain variables purposely omitted from the discussion for the sake of clarity. These include the effects of acute hypoproteinaemia, hæmoconcentration, adrenal insufficiency, and the action of hypothetical toxins, all of which may complicate the shock syndrome. These variables probably do not alter the fundamental nature of hæmatogenic shock, but when present they influence the rate of progression to a state which will be discussed below under the heading of 'decompensated shock'.

Clinically, all forms of uncomplicated hæmatogenic shock are characterized by the fact that the blood-pressure may be normal, and if too much reliance is placed upon this sign, a state of severe shock may be overlooked. This is particularly true of the more slowly progressive cases in which compensatory mechanisms become established.

**Decompensated Shock.**—The common denominator in hæmatogenic shock, regardless of the type of fluid lost, is an actual reduction of the blood-volume. Once this occurs, a train of secondary events is set in motion, which, although the rate of progression and the exact sequence



of events may vary in the different types of shock, leads to a state which might be termed 'secondary' shock, meaning secondary to a prolonged reduction of the blood-volume. However, because the term 'secondary shock' has been used for so many years as synonymous with 'traumatic shock' or 'surgical shock' and because it fails to imply the advanced and perhaps irreversible character of the syndrome, the term 'decompensated shock' is suggested. The fact that the

factors, there should be no difficulty in distinguishing the two conditions on clinical grounds by the time factor as well as the generally poorer condition of the patient in decompensated shock. Decompensated shock, particularly if complicated by a general anaesthetic, often passes into an irreversible stage in spite of therapy.

Not only may the various types of shock lead one to another, and eventually to decompensated shock, but in any given patient more than one type may be initiating factors. The situation may be depicted diagrammatically as in Fig. 29. Failure to appreciate the interplay of the many variables which may contribute to the 'vicious circle' of shock has led to considerable controversy, certain aspects of which merit discussion and an attempt at clarification.

### THE CONTROVERSY ABOUT HÆMORRHAGE AND SHOCK

Some investigators have attempted to draw a sharp distinction between hæmorrhage and shock. In recent years this view has been especially championed by Moon (1938). From a practical point of view this is a great mistake. As Harkins (1941) says, "In clinical cases usually both whole blood and plasma are

lost. After all it matters little what colour fluid is lost from the blood-stream, red or yellow". The problem resolves itself largely into a matter of semantics. If shock is defined as 'a state of actual, or impending, peripheral vascular collapse due to a reduction of the effective blood-volume', then, hæmorrhage must be included. Specifically it constitutes a particular form of hæmatogenic shock.

That there are important differences between simple hæmorrhage and shock associated with the loss of plasma which accompanies a severe burn, no one can question. In burns the reduction of the blood-volume is complicated from the beginning by hæmoconcentration, marked depletion of the total plasma protein, acidosis, gross destruction of tissue, and possibly adrenal cortical insufficiency. Thus, there is a very rapid progression from the early stages of hæmatogenic shock to fully established decompensated shock. On the other hand, in hæmorrhage, the reduction of the blood-volume is well tolerated unless it is maintained at a low level for a considerable period of time, or is complicated by other factors such as anaesthesia. Although there is some doubt as to whether a state of irreversible shock can be produced by hæmorrhage alone (Price et al., 1941), Blalock (1934) has observed hæmoconcentration, an unfavourable response to transfusion, and

### THE VICIOUS CIRCLE OF SHOCK

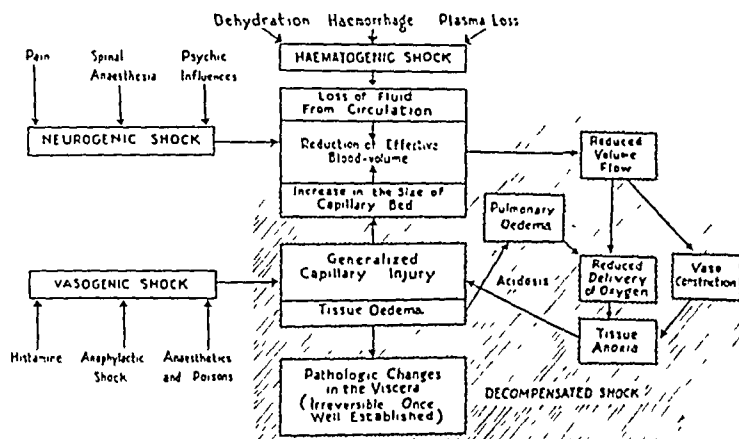


FIG. 29.—A diagrammatic representation of the many variables which may enter the shock syndrome. Such theoretical conceptions are useful in teaching, or as a basis for discussion, but it is not certain that the sequences occur exactly as represented.

word decompensation has been used specifically in relation to cardiac failure, does not vitiate its use in advanced shock, since the recent studies of Wiggers (1942) suggest that in this condition the factors which finally determine a fatal issue are cardiac in nature.

Decompensated shock is characterized by a lowered venous return, a diminished cardiac output, a low arterial pressure, decreased oxygen consumption, hypoproteinæmia, acidosis, and anoxia. Additional contributing or terminal factors, regardless of the original cause, may be progressive hæmoconcentration from loss of fluid through damaged capillaries, adrenal cortical insufficiency, hyperpotassæmia, and the action of toxins or metabolites from injured tissues. The summation of these factors leads to a death which is characterized pathologically by dilated and congested capillaries, capillary hæmorrhages, oedema, and degenerative changes in parenchymous tissues throughout the lungs, liver, kidneys, and gastro-intestinal tract.

Clinically, decompensated shock is manifested by ashen-grey pallor, a weak rapid thready pulse, shallow respiration, a cold moist skin, mental apathy, subnormal temperature, and a low blood-pressure. This is advanced, or late, shock. Although it may be simulated by an early stage of hæmatogenic shock complicated by neurogenic

histologic evidence of capillary injury as a result of uncomplicated hæmorrhage in unanæsthetized animals. Moreover, in practice the problem of hæmorrhagic shock is not that of simple hæmorrhage, but that of hæmorrhage accompanied by varying degrees of tissue injury from trauma, with plasma loss, variable neurogenic factors, and often the hazards of anæsthesia. In this situation the important and decisive factor is the loss of blood. Hæmoconcentration and hypoproteinæmia are not early or prominent factors, but eventually there develops a degree of shock which is characterized by all the usual features of this state, including the same post-mortem histologic changes. These facts justify the inclusion of hæmorrhage as a form of hæmatogenic shock. In military surgery it is the most important form.

### HÆMOCONCENTRATION

In recent years there has been a renewed interest in, and considerable emphasis on, hæmoconcentration as an early sign of shock (Moon, 1938). It is of interest that the significance of hæmoconcentration was pointed out by Sherrington in 1893, and was used as a guide to prognosis during the last war (1923). When interpreted correctly it is a valuable sign, especially as a guide to therapy, but it is by no means invariably the earliest sign of shock. It is an early and invariable accompaniment of dehydration and loss of plasma, but it does not occur in neurogenic shock or hæmorrhage, and may develop comparatively late in conditions ascribed to vaso-genic shock. Progressive hæmoconcentration in

change in the concentration of the blood. Later, as hæmodilution occurs, there is a gradual fall in the hæmatocrit. If fluid is given to replace the loss of blood, the hæmatocrit falls rapidly. When plasma rather than blood is lost there is early and marked hæmoconcentration, the hæmatocrit rising to 60 or 75. Later, after hæmodilution occurs, or infusions have been given, it returns to normal. When whole blood and additional plasma are lost simultaneously, as in a crushing injury associated with hæmorrhage from another wound, the initial changes in the hæmatocrit are in the direction of concentration, but following therapy with fluid, because of the loss of blood, the late findings indicate hæmodilution. An appreciation of these facts is of fundamental importance, and their application in the treatment of shock is dependent upon a close correlation of the laboratory findings with the clinical history.

### THE PULSE AND THE BLOOD-PRESSURE IN SHOCK

The unreliability of the blood-pressure in shock was emphasized in 1919 by Gesell and has been re-emphasized by many workers in this field. This does not mean that it is a useless sign. Indeed, Kekwick, Marriott, Maycock, and Whitby (1941) found it to be the most valuable single sign in their experience with air-raid casualties. Once again it is a matter of correct interpretation in the light of all available evidence. If there are factors which produce a loss of vaso-constrictor tone, or generalized capillary injury, the arterial pressure will be low. Thus it is low in neurogenic shock without necessarily being of grave import. If there is an actual reduction of the blood-volume from loss of blood or plasma, there may be a low pressure at first from neurogenic factors, and if the shock is severe there may be no reaction from fall in pressure. Usually, however, after pain and fear have been relieved, compensatory vasoconstriction will return the arterial pressure to normal, or even above normal levels despite a continued reduction of the blood-volume. This phase of temporary hypertension, sometimes associated with variations in the blood-pressure (Traube-Herring waves) frequently occurs in experimental shock. It is less

obvious clinically, but McMichael (1942) noted it in his study of a series of air-raid casualties. Finally, the blood-pressure is low in decompensated shock regardless of cause.

When confronted with a low blood-pressure one must decide on the basis of the available evidence, whether it is the result of neurogenic, a combination of neurogenic and early hæmatogenic,

### HÆMATOCRIT CHANGES IN SHOCK

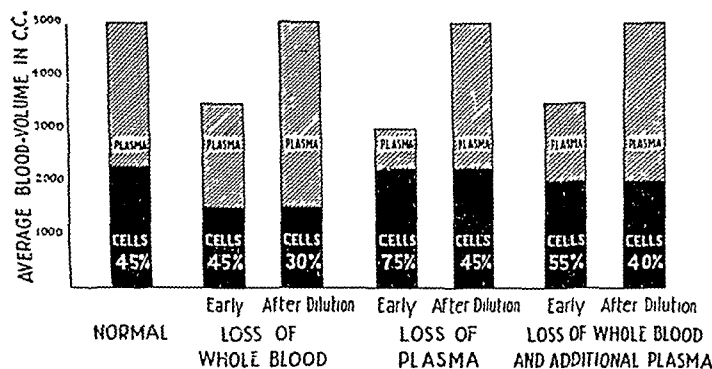


FIG. 30.—Possible variations of the hæmatocrit in shock (after Harkins).

spite of adequate replacement therapy may occur in advanced shock. It is a variable finding and difficult to interpret when whole blood and additional plasma are lost simultaneously.

The possible variations of hæmatocrit readings have been well described (Harkins, 1941; Mahoney and Howland, 1943) (Fig. 30). In the early stage of acute hæmorrhage there is no

or decompensated shock. Conversely, a normal or even high blood-pressure must not lead one to overlook hæmatogenic shock at a time when replacement fluid may be urgently required, and, if given promptly, decompensated shock averted. Determinations of the hæmatocrit and plasma protein may be of value in trying to interpret the significance of a low blood-pressure, but the most important evidence is obtained from a careful evaluation of the clinical history.

Hill, McMichael, and Scharpey-Schafer (1940) found that a continued elevation of the pulse-rate, even after adequate replacement therapy, was not an unfavourable sign in shock. Conversely, they, and others, noted very slow rates after severe hæmorrhage (Ebert et al., 1941; Wallace and Sharpey-Schafer, 1941). However, if these facts are taken into consideration, careful repeated and thoughtful evaluation of the pulse, noting not only the rate, but the character and the quality, is a most helpful guide to prognosis and therapy. It is one procedure which the surgeon can always do, anytime and anywhere, and to the experienced it gives information of great value.

### CAPILLARY INJURY AND THE PATHOLOGY OF SHOCK

There is no doubt that local increased capillary permeability occurs at the site of extensive injuries. It has become axiomatic, however, that generalized capillary injury plays a major role in the vicious circle of shock. The actual evidence for this rests largely upon the established causal relationship between anoxia and increased capillary permeability. The importance of anoxia and its effect on the capillary bed in shock has been emphasized by many investigators (Harkins, 1941). Recently Root and Mann (1942) observed capillary dilatation and stasis in the liver and mesentery secondary to a local loss of fluid at the site of an injury. No positive evidence was found for the liberation of a toxic substance causing immediate capillary damage in the types of shock studied. Fine and Seligman (1943), in a study of the behaviour of proteins 'tagged' with radio-active sulphur, found evidence of capillary permeability only in the very late stages of experimental shock due to hæmorrhage.

That a generalized abnormal capillary permeability occurs in the terminal stages of shock seems well established. This is quite a different thing from the extreme position taken by Moon (1938), who describes a wheal as shock in miniature, and holds that, regardless of cause, capillary injury is a primary factor. Apart from assumption, the principal evidence which Moon presents for generalized capillary injury as a fundamental factor in all forms of shock, are his morphologic studies of the viscera of animals who have died in shock. However, if the time factor is taken into consideration, the histologic changes in shock due to burns and trauma are essentially the same as in hæmorrhage. Moreover, these develop

only after the blood-volume has been reduced by a local loss of fluid at the site of injury, and appear, therefore, to be a secondary rather than a primary phenomenon (Dunphy et al., 1941).

The situation may be summarized as follows: (1) By definition there is no capillary injury in neurogenic shock. (2) By definition capillary injury is the fundamental factor in vasogenic shock, but at present there is no convincing proof that capillary injury occurs as a primary phenomenon in any of the clinical states classified as vasogenic shock. Therefore, final judgement must be withheld until the situation is clarified by further study. (3) The principal argument centres about hæmatogenic shock, in which the available evidence indicates that capillary injury occurs as a late and purely secondary phenomenon, the principal evidence for which are the pathological changes which occur throughout the viscera. Although these late changes are interpreted to be a consequence of capillary injury, it is quite possible that generalized tissue injury, especially in highly specialized organs such as the brain, liver, or adrenals, occurs long before the capillaries are damaged. The use of a tourniquet in surgical operations is ample evidence that the capillaries of the leg can withstand ischæmia for longer periods than the tissues of the liver or brain. Indeed, by future study, the response of the capillaries to injury may prove to be secondary to tissue injury.

### THE ROLE OF THE ADRENAL GLAND

A discussion of all the evidence, for and against, both hyper- and hypo-activity of the adrenal gland, in shock is not within the scope of this paper. There is no doubt that the adrenal medulla exerts an action in hæmatogenic shock by contributing to the generalized compensatory vasoconstriction which accompanies a reduction of the blood-volume. Since this action primarily safeguards vital centres which might otherwise be deprived of blood, it should be regarded as a homeostatic phenomenon. There is not sufficient evidence to consider adrenal medullary activity as either a primary cause or a principal secondary factor in the peripheral circulatory failure of shock.

The evidence for the adrenal cortex playing an important role in shock centres about the following: a shock-like state follows bilateral adrenalectomy in the experimental animal; adrenalectomized animals are more susceptible to shock following trauma than normal animals; certain pathological changes appear in the adrenal gland in shock, especially in burns; and the course of clinical and experimental shock has been reported to be favourably altered by a number of investigators using a variety of adrenal cortical hormones. On the surface this looks like an imposing array of evidence, but actually there is little solid proof for the action of the adrenal cortex as a primary factor.

Until further evidence is available the role of the adrenal gland and the value of adrenal cortical extract in the treatment of shock should be regarded as controversial subjects requiring further study (Mahoney and Howland, 1943).

### THE THEORY OF TOXAEMIA

At present there is no proof of a specific toxin as a primary factor in neurogenic or hæmatogenic shock. The nature of vasogenic shock implies that the causative agent produces a specific injury to the capillaries and hence quite properly can be referred to as a 'toxin'. Histamine shock is a good example, but with the possible exception of anaphylactic shock there is not sufficient evidence to place any clinical states categorically in this classification. Thus Ebert and Stead (1941) have shown that the circulatory failure of severe infections is not associated with hæmoconcentration or a decrease in plasma volume. On the other hand, in decompensated shock, particularly that which follows burns or crushing injuries, the possibility that products of injured tissue enter the circulation and play a role in the irreversible stage of shock cannot be excluded. That an irreversible state may develop is undoubted. It has been noted clinically by many observers. Experimentally, it has been shown that complete restoration of the blood-volume by replacement therapy is without avail in the late stages of severe burns (Dunphy and Gibson, 1941).

The observations of Duncan and Blalock (1943) demonstrate the irreversible character of the shock which follows release of a tourniquet from an ischæmic traumatized limb, and the studies of Bywaters (1941) on the crush syndrome in man afford ample evidence that the products of muscle catabolism may enter the circulation. Of especial interest and importance is the identification of the chemical nature of a shock-producing factor isolated from normal striated muscle by Green (1943). These observations represent a real advance in the search for a toxic factor. However, at present direct applicability to the problem of shock in man is limited to additional emphasis on the hazards of the use of a tourniquet to control bleeding in damaged limbs.

Govier (1943) has shown that animals which have been given large doses of thiamine have an increased resistance to shock induced by hæmorrhage. While Maycock (1943) has been unable to confirm these observations, this approach to the problem of late shock as one of altered cellular metabolism may prove fruitful. Also of interest in this respect are the experimental observations of Mylon and his co-workers (1943). They have found that injections of small amounts of agents such as methylene blue or sodium succinate, which may have an effect on tissue respiration, will not only produce a rise in arterial pressure in late shock, but when given with replacement

fluid appear to increase the survival rate over that obtained with fluid alone.

### THE DIAGNOSIS OF SHOCK

The invaluable studies of air-raised casualties in the early years of the present war show that chief reliance must be placed on experience and sound clinical judgement in recognizing the various stages of shock, and in evaluating the effects of, and indications for, treatment (Grant and Reeve, 1941; Kekwick et al., 1941). If a patient is admitted in apparent collapse, with a blood-pressure which is hardly measurable, but with warm extremities and a pulse which is only moderately elevated and of fair quality, and if, furthermore, the history reveals that although thrown from a vehicle he landed on soft ground, and no evidence can be found for fracture or other grave injuries, he cannot be considered to be in advanced or decompensated shock. Neurogenic shock is more probable, but one must be guarded in a prognosis until further observation excludes the possibility of intra-abdominal injury with internal bleeding. It must be remembered that in hæmorrhage vasovagal reflexes may produce a slowing of the pulse quite similar to that seen in ordinary syncope. Assuming no such factors, such a patient will recover promptly, and to ascribe recovery to the use of some adrenal cortical hormone is, to say the least, unsound.

On the other hand, if a patient is seen with a compound fracture of the femur, multiple lacerated wounds, and a possible abdominal injury, one must not overlook established hæmatogenic shock because the blood-pressure is normal and the pulse-rate is only 110. Every effort to appraise accurately the state of this patient's circulation must be made. It is under such circumstances that determinations of the hæmatocrit and serum protein are often helpful. These determinations, while by no means indispensable, are an aid to early diagnosis and may be of value in determining the type and amount of fluid replacement required. This is particularly true in hæmatogenic shock when the fluid loss is severe and chiefly of one type.

It must be emphasized that a changing hæmatocrit is of far more value than a single determination. Progressive hæmoconcentration in spite of therapy is a sign of decompensated shock. Even in the presence of hæmorrhage, repeated determinations of the hæmatocrit may be helpful. Determinations made after replacement therapy with plasma will show a marked reduction, and often give evidence of the severity of the initial blood-loss. Continued hæmodilution after transfusion with blood may indicate continued bleeding in doubtful cases.

A hæmoglobin determination by the Sahli technique will afford sufficient information for clinical purposes. Nor is it essential to have any of these laboratory procedures. They should be looked upon as supplementary and confirmatory

procedures, and of value in the study of shock. But if one knows from the history that a patient has lost a litre of blood, one need not wait for laboratory data to transfuse. Common sense and ordinary clinical acumen and thoroughness will save more patients and provide better shock therapy than all known laboratory procedures.

### TREATMENT OF SHOCK

Uncomplicated neurogenic shock probably would always recover without treatment, but recovery seems to be hastened by rest with the head slightly dependent, sedation, and warm drinks, and thus the possible effects of associated injuries are more readily evaluated. Failure of neurogenic shock to improve promptly under such measures should immediately stimulate a further search for unrecognized injuries. Whenever there is capillary or tissue injury, local or generalized, the use of saline may be dangerous, but in neurogenic shock there is no capillary injury and the factors which bring about an increase in the size of the vascular bed are of short duration. A saline infusion increases the blood-volume temporarily, but escapes from the circulation as the vascular tone is restored to normal. It is especially useful in treating the hypotension of high spinal anaesthesia.

The treatment of vasogenic shock remains an hypothetical problem since at present it is not clear precisely what clinical conditions belong in this category. It appears evident that measures directed toward removal of causative agents are of greater importance than measures designed to improve the peripheral circulatory failure (Ebert and Stead, 1941).

The treatment of haematogenic shock falls into three categories: (a) General supportive measures; (b) Restoration of the blood-volume by the most suitable means available; (c) Supplementary measures of doubtful value.

**General Supportive Measures.**—The time-honoured measures of the Trendelenburg position, morphine, and the application of heat are open to certain criticisms in the light of newer knowledge. The so-called 'shock position' is of value in neurogenic shock and as an emergency procedure in haematogenic shock until the blood-volume has been restored by replacement therapy. Since it causes a certain degree of cardiac and respiratory embarrassment it should not be used to an extreme degree. If the head is very slightly below the horizontal, full benefit from this position will be obtained with little of the disadvantages. After restoration of the blood-volume by replacement therapy there is no need for the continued or routine use of the head-down position.

It is now well established that heat, as furnished by many hot-water bottles wrapped up in blankets, or by the so-called 'shock cradle', is detrimental. It increases the metabolism of peripheral tissues when available blood and oxygen

are needed elsewhere. On the other hand, despite some suggestive evidence that cold may have a beneficial influence, there is no sound basis for its use. A common-sense attitude of maintaining normal body warmth should be adopted. The term 'prevention of exposure' should be substituted for 'application of heat' in the treatment of shock.

The value of morphine is unquestionable, but it is to be used to relieve pain and not as a routine procedure. The beneficial effects of morphine are due to its alleviation of factors contributing to neurogenic shock. When given repeatedly without indication it serves only to depress the respiratory centre and possibly aggravate an already existing anoxia.

The importance of promptly splinting fractures and extensive wounds before transportation of patients cannot be over-emphasized. It is as important as in the last war, and fortunately is fully appreciated.

**Restoration of the Blood-volume.**—If a man loses five litres of blood slowly over a period of hours he will die, and he will die of shock. If he is transfused with five litres of blood, and if these transfusions are given so that the blood-volume is maintained at all times, he will not die. This, in the simplest terms, is the treatment of haematogenic shock. Moreover, without blood or plasma, no amount of drugs, adrenal extract, or oxygen will benefit this patient.

So it is in all forms of haematogenic shock. The primary consideration is to maintain the blood-volume. No fluid, not even plasma, remains in the blood-stream. It is poured into the area of injury, not in the form in which it was given, but as diluted plasma. This is an extremely important fact which Beard and Blalock first presented in 1931. It represents one of the most important advances in our knowledge of shock. If the fluid is not replaced in the form in which it is lost, the various constituents of the blood may be washed out into the area of injury. For this reason the use of saline solutions in shock accompanied by loss of plasma may be dangerous. Although such solutions produce a temporary rise in the blood-volume, this is of short duration and results in such dilution of the blood that the serum proteins are quickly reduced to oedema levels. Moreover, as the fluid leaks out of the blood-stream as dilute plasma, it increases still further the rate of protein loss. As a consequence of protein depletion to oedema levels, fluid is lost not merely into an area of injury, but throughout the viscera, pulmonary oedema being an obvious manifestation. The use of saline infusions should be reserved, therefore, for those conditions in which shock is clearly neurogenic or the result of dehydration from loss of water and electrolytes.

In military surgery, the majority of cases of shock are either due to or complicated by haemorrhage. Although as previously pointed out, determination of the haematocrit or haemoglobin

after replacement with plasma may be helpful, reliance must be placed chiefly on the history and clinical examination of the patient. In general, if an infusion is needed at all, 1000 c.c. represents a minimum requirement. If the history and physical examination indicate a loss of blood or plasma or both, this should be started at once and given rapidly, the first 500 c.c. within ten to twenty minutes. If more than 1000 c.c. of plasma is required to bring about or maintain a response, 500 c.c. of whole blood should be given. With each additional litre of replacement fluid required, at least 500 c.c. of blood is given. If improvement is not obtained after 2000 c.c. of replacement fluid and there is a great demand for plasma and blood for other casualties, the situation should be reviewed and consideration given to the possibility that one is dealing with a hopeless case. On the other hand, if a favourable response occurs, there is practically no limit to the amounts which may be given to maintain the circulation.

In cases in which there is continued bleeding it is of vital importance not to delay essential surgery. It is useless to transfuse and delay. Preparation for surgery should be carried out as the shock is treated, and as soon as the arterial pressure rises to 90 mm. or 100 mm. Hg, or higher, the pulse slows appreciably, the extremities improve in warmth and colour, and the estimated fluid loss has been replaced, operation should be done, *but*, at the same time *therapy must be continued* until the bleeding is controlled and a good circulatory state maintained. In severe cases 5000–6000 c.c. or more may be necessary. Whole blood in addition to plasma is of vital importance in treating severe shock due to hæmorrhage, particularly when extensive surgery with prolonged anæsthesia is required. The use of plasma as a complete substitute for blood has proven singularly disappointing.

There are several useful ways of estimating the amount of plasma required in severe burns. The 'first-aid formula' of Harkins (1941) is especially useful. This calls for one pint of plasma for each 10 per cent of body area burned. Since this gives the total amount required it should be given over a period of about 12 hours. If a hæmatocrit or hæmoglobin estimation can be done the following formulæ are simple and valuable:

a. Plasma required =  $\left(5 - \frac{500}{\text{Hb}_2}\right) \times 1000$ , in which Hb<sub>2</sub> is the hæmoglobin observed after the burn (Black, 1940).

b. For each point the hæmatocrit is elevated above the normal of 45 give 100 c.c. of plasma (Harkins, 1941).

Both these formulæ should be familiar to those who treat the shock of severe burns. It is unwise, however, to place complete reliance upon them, and in addition to using them as a guide to requirements, the actual response of the patient to therapy should be used as an indication for additional

requirements. In general, it is better to err on the side of too much rather than too little replacement when dealing with young subjects without cardiovascular disease.

**Supplementary Measures.**—These include such measures as hypertonic solutions, oxygen, coramine, and adrenal cortical extracts. The situation may be summarized by repeating that if a patient loses five litres of blood over a period of hours he will die in profound shock. If he is transfused with five litres of blood so as to maintain the blood-volume he will not die, and no other therapy is required to save his life. Moreover, without blood and plasma no amount of concentrated solutions, drugs, oxygen, or cortical extracts will save this man's life. This is not to say that these supplementary measures have no place in shock therapy, but in general their use has not been proven essential, and their place should be considered secondary to measures designed to restore the lost fluids by volume-for-volume replacement.

The recognized anoxia of shock would seem to make oxygen therapy essential, but the anoxia of shock is primarily circulatory and if the circulation is restored by transfusion there is little need for oxygen unless there are specific indications for its use, such as marked dyspnoea, cyanosis, air hunger, or specific disease or injury of the chest. Again, from a practical point of view the difficulties attendant upon properly administering oxygen, plus the discomfort caused the patient, may interfere with, or delay, more vital forms of therapy. It should be used whenever specifically indicated, but not as a routine.

Adrenal cortical extract may have a place in the treatment of severe burns as an adjunct to plasma infusions, but in general its use, as well as that of various drugs, should be viewed as largely experimental and certainly not of primary importance in the practical treatment of shock.

Highly concentrated solutions of plasma and albumin are also of doubtful value in the therapy of shock. As a means of providing large amounts of available protein in small packages for ease of transport, concentrated or dried preparations have a place in military surgery. This particularly applies to albumin, which is admirably suited for transportation because of its stability in a 25 per cent solution. Whether these preparations should be used in concentrated forms, however, is a matter for conjecture. It is possible that a single infusion of a concentrated protein solution given in the early stages of shock, in a patient in whom there is no marked dehydration, may mobilize additional fluid reserves more rapidly than normal and thus maintain the circulation until blood or plasma is available. In conditions such as severe burns, in which the local loss of fluid is enormous, concentrated solutions in addition to dilute isotonic fluid replacement may prove beneficial in limiting local œdema. On the other hand, it is obvious that if the loss of fluids is prolonged and severe, and especially

if there is associated dehydration, adequate replacement of the lost fluids cannot be accomplished with hypertonic solutions. The lost fluid must be replaced in the form in which it is lost, which means giving blood or dilute plasma, or both.

It should be obvious from the foregoing that there can be no adequate substitute for blood and plasma in the treatment of severe hæmatogenic shock. Inasmuch as any form of replacement fluid enters the area of injury diluted with plasma, and amounts of 1500 to 2000 c.c. represent minimal requirements, it is evident that a major portion of the original blood-volume must be replaced by the infusion. Although possibly suitable for maintaining the blood-volume, substitutes such as gelatin, pectin, isinglass, or even albumin will not provide the essential requirements of blood. Experimental studies with bovine albumin indicate its limitations in this respect in comparison with plasma (Dunphy and Gibson, 1943). All blood substitutes must be recognized, therefore, as mere expedients, used because of greater availability or ease of transport, as a means of maintaining the circulation until blood or plasma can be given.

### SUMMARY

Shock is defined as "a state of actual, or impending, peripheral circulatory failure due to a reduction of the effective blood-volume which is not primarily cardiac in origin".

Depending upon the mechanisms involved, three types are postulated: *neurogenic*, a state of widespread vasodilatation without primary capillary injury; *vasogenic*, a consequence of a direct injury to the walls of capillaries; and *hæmatogenic*, the result of a primary loss of fluid from the circulation. The term *decompensated shock* is applied to the physiological sequences which follow a prolonged reduction of the effective blood-volume, regardless of the original cause or causes.

Particular emphasis is placed on the necessity for an evaluation of the entire clinical picture in recognizing the earliest stages of shock and in determining the need for, and the efficacy of, various forms of therapy.

The fundamental treatment of shock in military surgery resolves itself into the prompt replacement of blood with blood, and plasma with plasma; the limitations of blood substitutes and

the secondary importance of all other forms of therapy are stressed.

### REFERENCES

- BEARD, J. W., and BLALOCK, A. (1931), *Arch. Surg., Chicago*, **22**, 617.  
 BLACK, D. A. K. (1940), *Brit. med. J.*, **2**, 893.  
 BLALOCK, A. (1934), *Surg. Gynec. Obstet.*, **58**, 551.  
 — (1940), *Principles of Surgical Care, Shock, and Other Problems*. St. Louis: The C.V. Mosby Co.  
 BYWATER, E. G. L., and BEALL, D. (1941), *Brit. med. J.*, **1**, 427.  
 CANNON, W. B. (1923), *Traumatic Shock*. New York: D. Appleton & Co.  
 DUNCAN, G. W., and BLALOCK, A. (1943), *Surgery*, **13**, 401.  
 DUNPHY, J. E., and GIBSON, J. G., jun. (1941), *Ibid.*, **10**, 108.  
 — — — (1943), *Ibid.*, **14**, 509.  
 — — — and KEELLY, J. L. (1941), *Surg. Gynec. Obstet.*, **72**, 823.  
 EBERT, R. V., and STEAD, E. A., jun. (1941), *J. Clin. Invest.*, **20**, 671.  
 — — — and GIBSON, J. G., jun. (1941), *Arch. intern. med.*, **68**, 528.  
 FINE, J., and SELIGMAN, A. M. (1943), *J. clin. Invest.*, **22**, 305.  
 FREEMAN, N. E. (1935), *Ann. Surg.*, **101**, 484.  
 GOVIER, W. M. (1943), *J. Pharmacol.*, **77**, 40.  
 GRANT, R. T., and REEVE, E. B. (1941), *Brit. med. J.*, **2**, 293; **2**, 329.  
 GREEN, H. N. (1943), *Lancet*, **2**, 147.  
 HARKINS, H. A. (1941), *Surgery*, **9**, 231.  
 HILL, D. K., McMICHAEAL, J., and SHARPEY-SCHAFER, E. P. (1940), *Lancet*, **2**, 774.  
 KEKWICK, A., MARRIOTT, H. L., MAYCOCK, W. D'A., and WHITBY, L. E. H. (1941), *Ibid.*, **1**, 99.  
 MAHONEY, E. B., and HOWLAND, JOE W. (1943), *Surgery*, **13**, 188.  
 MAYCOCK, W. D'A. (1943), *Quart. J. exp. Physiol.*, **32**, 29.  
 McMICHAEAL, J. (1942), *Brit. med. J.*, **2**, 671.  
 MOON, V. (1938), *Shock and Related Capillary Phenomena*. New York: Oxford Univ. Press.  
 MYLON, E., WINTERNITZ, M. C., and DE SUTO-NAGY, G. J. (1943), *Amer. J. Physiol.*, **139**, 313.  
 PHEMISTER, D. B., and SCHACTER, R. J. (1942), *Ann. Surg.*, **116**, 610.  
 PRICE, P. D., HANLON, C. R., LONGMIRE, W. P., and METCALF, W. (1941), *Bull. Johns Hopk. Hosp.*, **69**, 327.  
 ROOT, G. T., and MANN, F. C. (1942), *Surgery*, **12**, 861.  
 SHORT, A. R. (1913), *Brit. J. Surg.*, **1**, 114.  
 STEAD, E. A., jun., and EBERT, R. V. (1942), *Arch. intern. Med.*, **69**, 369.  
 WALLACE, J., and SHARPEY-SCHAFER, E. P. (1941), *Lancet*, **2**, 393.  
 WIGGERS, C. J. (1942), *Physiol. Rev.*, **22**, 74.



## CHOLESTEATOMA OF THE PETROUS BONE

By JOE PENNYBACKER

FROM THE NUFFIELD DEPARTMENT OF SURGERY, OXFORD

PROGRESSIVE paralysis of the facial nerve is not a very common affection. When it does occur, pressure on the nerve by a neoplasm is a likely cause, and when the facial paralysis is accompanied by deafness and absence of the caloric responses on the same side, the tumour is commonly in the cerebello-pontine angle, e.g., an acoustic neurinoma. In other cases, the nerve may be subjected to pressure in its course through the petrous bone, and this report is concerned with three such cases recently encountered in the Nuffield Department of Surgery in which the lesion was found to be a cholesteatoma in the petrous bone.

## CASE REPORTS

## Case 1.—

**HISTORY.**—A medical practitioner, aged 42, was admitted to the Radcliffe Infirmary on May 12, 1941. In November, 1938, he was first aware of some right facial weakness, his attention being drawn to it by food collecting in the right corner of his mouth, and by his inability to whistle properly. Some weeks later the weakness was slight enough to have been missed in an examination for life insurance.

In February, 1939, three months after the onset of the facial weakness, he had an attack of otitis media on the right side. So far as he knew, he had never had any trouble with his ears before. After forty-eight hours of earache, the drum burst and there was a little blood-stained purulent discharge for a week. There had been no recurrence of pain or discharge, but from the time of this infection there had been a considerable deafness of the right ear. Although the patient was fully aware of the facial palsy during this illness, it was still slight enough to have missed detection by the aural surgeon who attended him.

It is difficult to say how long it took the palsy to become complete, but it was not until June, 1940 (at least eighteen months after the weakness was first noticed) that he sought advice about it. Probably the palsy had been fairly complete for some months before this, as the patient took rather an optimistic view of the affection and was loath to admit that the paralysis was ever complete.

**ON EXAMINATION.**—He was a healthy man and there were no neurological abnormalities, except a complete right facial paralysis, with some fibrillation at the right angle of the mouth. There was impairment of the sense of taste on the right side of the tongue. He was very deaf in the right ear: with a noise box in the left ear he could only hear loud shouts at 1 ft. in the right ear; the hearing in the left ear was clinically normal, but the audiogram showed some loss of high tones on the left side too. The Weber was referred to the right. A.C. was greater than B.C. on both sides, but there was some relative loss of bone conduction on the right side as compared with the left. Our otological colleagues identified this as a mixed type of deafness, and in any case it seemed out of proportion to the history of a mild otitis media and the appearance of the drum: the right drum was intact, but there was a small scar behind the handle

of the malleus. The left drum was normal. The caloric responses were absent on the right side, but were normal on the left. Radiographs (Fig. 31) of the skull showed an erosion of the upper surface of the petrous bone medial to the mastoid antrum, but

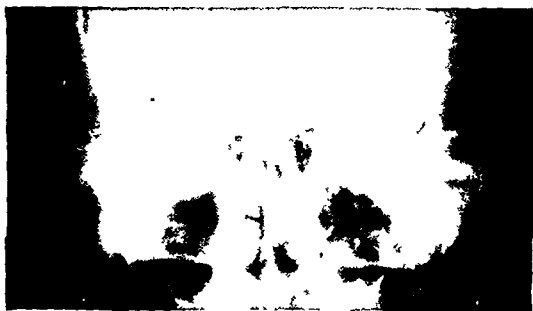


FIG. 31.—Case 1. Radiograph showing erosion of the superior surface of the right petrous bone.

no other abnormalities. The mastoid air cells were of about normal translucency.

The important negative findings were that the optic fundi and visual fields were normal, as were the pupils and external ocular movements. There was no sensory impairment in the trigeminal area and no abnormality in the functions subserved by the lower cranial nerves. In his limbs there was no dystonia, inco-ordination, or weakness, no abnormality of the reflexes, and no disturbance of gait. The cerebrospinal fluid was normal as to pressure and content.

This patient was seen some months before he was admitted to hospital, and the findings of progressive facial palsy, deafness, and absence of caloric responses led to the provisional diagnosis of an acoustic neurinoma in the very early stages of its development. I was not familiar with the X-ray appearances, but Professor Cairns thought that these appearances and the clinical state were likely to be due to a cholesteatoma of the petrous bone.

**AT OPERATION.**—As there was no evidence of active mastoid infection, and as the radiographs suggested that the lesion should be accessible by way of the middle fossa, we operated on May 19, 1941, by the approach commonly used for section of the trigeminal root. The dura was elevated from the upper surface of the petrous bone without difficulty. There was an irregularly oval erosion of the petrous bone anterior to the arcuate eminence measuring about 1.2 cm. in its longer axis. The defect was filled with soft, cheesy white material which could be lifted out in little chunks with a blunt hook or a small spoon. An irregular cavity was cleared of this material, and the facial nerve could be seen bared up to the genu. It was intact but flattened. The bone forming the walls of the cavity looked normal, but a fragment removed for histological examination showed some thickening of the periosteum and chronic inflammatory infiltration.

**PROGRESS.**—The wound healed normally and the patient resumed his practice about a month after



operation. He has remained well for the ensuing two and a half years, but there has been no improvement in the facial palsy. The muscles have been treated with galvanism from the time of operation, and although they have retained both their bulk and

May 21, 1922, a lesion very similar to that in the first case was found. The facial nerve was identified in the cavity and it was found although firmened. The wound healed normally, and he was discharged at the end of ten days.



FIG. 31.—Case 1. Photographs taken five days after operation, showing left facial paralysis as before operation.



contractility, there is no voluntary movement nor any response to faradism. The deafness is unaltered, and there has been no recurrence of the attacks or discharge.

**CASE 2.**—This case was rather more dramatic in its onset.

The patient was a man of 60 who had had a discharging left ear in childhood resulting in considerable deafness of that ear, although there had been no recurrence of the discharge. Two years before admission he had been aware of occasional spasms in the muscles around the left eye, and a year before admission he began to have attacks of gross spasmodic contraction of the left facial musculature: he described the phenomena as "working up and down like a piston", and at times the whole of the left side of his face was convulsed by irregular jerking movements. These were probably coarse fibrillations, but his description was so vivid that the question of focal epileptic attacks had to be considered. The facial weakness meantime was progressive, and about three months before admission, one of these spasms resulted in a complete left facial palsy, at least nine months after the onset of symptoms.

**ON EXAMINATION.**—He was a healthy man with a complete facial palsy on the left side (Fig. 32). He was very deaf in the left ear: with a noise box in the right ear, he could hear only loud sounds with the left ear. Weber was referred to the left. A.C. > B.C. right; B.C. > A.C. left. Both ear drums were somewhat dull, but otherwise normal. The caloric responses were absent on the left side but were present on the right. There were no other neurological abnormalities, and the spinal fluid was normal. Radiographs (Fig. 33) revealed an area of erosion of the petrous bone similar to that seen in the first case. The diagnosis was in no doubt in this case, and at operation on

By December, 1922, there was definite evidence of recovery, and this has continued until now he is able to close his eyes and to innervate the whole of the left side of his face (Fig. 34). It is interesting that his face now shows the phenomenon of mass innervation, i.e., he is not able to innervate one part without



FIG. 32.—Case 2. Lateral projection of left petrous bone, showing erosion of superior surface.

the whole. Thus when he is asked to show his teeth, the orbicularis oris contracts as well; and when he is asked to close his eyes firmly, the angle of his mouth moves. This phenomenon is well known in recovery from other types of facial paralysis, and it occurs in recovery from peripheral nerve lesions in other parts of the body.

*Case 3.*—This case calls for no special mention: it was that of a man of 53 who had had a facial palsy for four years. It came on so gradually that he could not say how long it took to become complete, but it had probably been so for at least two years before

## DISCUSSION

These cases present many common features. They all had a peripheral facial palsy of gradual onset. In two of them there had been infection

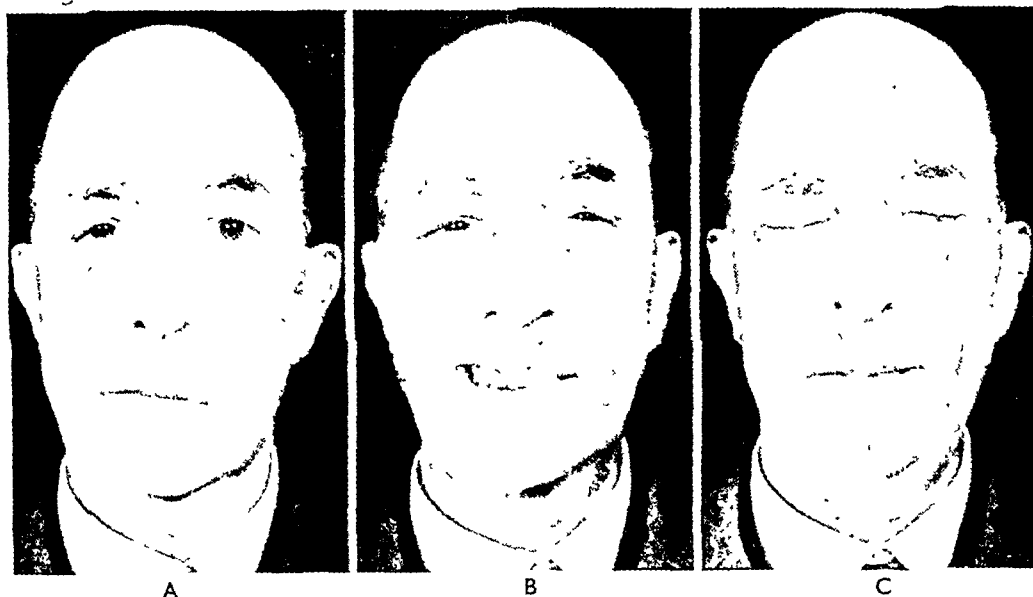


FIG. 34.—Case 2. Photographs taken one year after operation. A, At rest; B, Showing teeth; C, Closing eye.

admission. He had had an attack of suppurative otitis media on the left side twenty-five years before, but, after discharging for about two weeks, this infection cleared up and he had had no further trouble with his ear. On admission there was a complete facial palsy on the left side, impairment of taste on the left side of the tongue, gross middle-ear deafness on the left side, a large dry perforation of the left drum, and absent caloric responses on the left side.



FIG. 35.—Case 3. Radiograph showing erosion of superior surface of left petrous bone.

The spinal fluid was normal, and radiographs (Fig. 35) showed an erosion of the petrous bone similar to that described above. At operation on March 22, 1943, a similar lesion to those in the first two cases was found. The wound healed normally and he was discharged in ten days. It is unlikely that any recovery will occur in this case, as although the galvanic reaction was present when he was seen as an out-patient, it was uncertain when tested immediately before operation.

of the middle ear many years previously—in one twenty-five years and in the other about forty-five years—with no subsequent history of ear trouble. In the third case, the first evidence of aural infection of which the patient was aware occurred several months after the onset of the facial paralysis. In each case there was deafness of the homolateral ear, of a predominantly middle-ear type, and in each of them the deafness was more marked than one would have expected from the trivial nature of the aural infection. The caloric responses were absent. The sense of taste was impaired or lost in all cases. The neurological examination otherwise was negative, and in particular there was no evidence of increased intracranial pressure, nor of any disorder of the ocular movements such as nystagmus, nor of any trigeminal impairment. In each case the spinal fluid was normal. Radiographs of the skull showed an area of erosion in the petrous bone which was obvious in the routine axial views. The pathological findings at operation were similar in the three cases. There was erosion of the upper surface of the petrous bone by a soft, flaky white mass, creating a cavity in which the facial canal was bared between the internal acoustic meatus and the genu, and the nerve was subjected to compression. This soft white material had the naked-eye characters of a cholesteatoma, of the sort seen within the dura and bone elsewhere. Histologically it is laminated eosinophil material, for the most part devoid of any cellular elements. It was sterile on culture and the petrous bone and middle ears have shown

no naked-eye appearance of active infection, although, as mentioned in one case, there was some chronic inflammatory infiltration and thinning of the periosteum in fragments of bone removed from the margins of the cavity.

Jefferson and Smalley (1938) reported 6 of these cases in 1938 and found references to 5 others in the literature of the previous twenty-five years. They held that these tumours are probably epidermoids of the embryonal inclusion type rather than the cholesteatoma often associated with chronic mastoid infections. Their reasons for this view were that in at least two of their cases there had never been any aural infection, and in the others the infection was remote in time and trivial in degree. They considered that the common site of these tumours was an unusual one to be related to mastoid disease, being in a part of the petrous bone where there are normally no air cells. They raised again the question of primary cause: does a congenital tumour which we call a cholesteatoma cause infection of the middle ear and mastoid, or is the cholesteatoma the product of chronic inflammation. This is a controversy which is not likely to be settled at once, but in favour of a primary infection it can be said that in 6 of the 9 cases (taking the two series together) there had been antecedent mastoid disease in the same side, and that the possibility of such an infection having been unnoticed or forgotten in the other cases cannot be excluded. We know, for instance, that occasionally a temporal-lobe abscess can result from an acute infection of the middle ear and mastoid which resolves completely and leaves no signs.

For practical purposes, the aetiology of these tumours is less important than their recognition clinically. Although they are benign lesions, if they are treated in time recovery may take place, as in one of the cases described above, and in one of Jefferson and Smalley's series.

The operative approach which we have used is similar to that for the middle-fossa division of the sensory root. Jefferson and Smalley approached them through the mastoid, but as in each of our cases the erosion was in the superior surface of the petrous bone, it was easily accessible from above. Careful X-ray studies would show which route was preferable, and a combined approach might be of value in some cases.

The operation should be done as soon as the diagnosis is made, and the same factors will influence recovery as operate in other cases of facial palsy. The best chance of complete recovery rests in operation before the paralysis is complete or as soon thereafter as possible. Electrical treatment should be continued after operation until recovery is certain, or until it is clear that no improvement can be expected, in which case other methods of re-innervation will have to be employed.

The differential diagnosis from cerebello-pontine angle tumours has already been mentioned. Enough has been said to show that that differentiation is not difficult. What is more difficult is saying whether or not these are Bell's palsies, and that, in fact, is what all of our cases were first thought to be. The mode of onset and the X-ray changes should leave the matter in no doubt if the possibility of this lesion is borne in mind. *It is probably not as uncommon as the literature would suggest: a careful study of any large series of facial palsies would probably reveal several examples.*

The ultimate potentialities of these tumours are uncertain. If they develop from embryonal rests which wait until middle life to produce symptoms, they must be very slowly growing, and apart from local destruction of the internal ear and facial nerves, they might allow a normal span of life without any further disability. It is possible that the tumour might erode the dura of the middle cranial fossa and invade the brain, but such an occurrence has not been described in any of the published cases.

### SUMMARY

1. Three cases of facial palsy due to cholesteatoma of the petrous bone are described.
2. The differential diagnosis from other causes of facial palsy is discussed.
3. It is suggested that the best chance of recovery in these cases rests in early operation and subsequent electrical treatment.

### REFERENCE

- JEFFERSON, G., and SMALLEY, A. A. (1938), "Progressive Facial Palsy Produced by Intratemporal Epidermoids", *J. Laryng.*, 53, 717.

## ADRENAL NEUROBLASTOMA

By T. A. OGILVIE

NEUROBLASTOMA occur almost entirely in infants and young children. The number of cases reported in the literature is approximately three hundred, and the experience of any one surgeon cannot include many examples of the disease. The diagnosis, as in the case reported here, may present difficulties both from the clinical and

histological aspects, and it is likely that many cases are only diagnosed late, when metastases are widespread, or at post-mortem examinations. With few exceptions, treatment has so far been quite ineffective, and if improvement is to occur, early diagnosis is essential as in other malignant conditions.

## CASE REPORT

E. W., female, aged 2 years 10 months, was admitted to hospital on May 8, 1941, with a history that for six months there had been a gradually increasing swelling of the abdomen. There was no lassitude, sickness, or pain, and the child otherwise appeared well. Micturition was normal, and bowels were regular.

ON EXAMINATION.—There was a tremendous enlargement of the abdomen, the girth of which was 27½ in. A firm, smooth, non-fluctuant mass filled most of the abdominal cavity, extending from the right costal margin down to the pelvis and well over to the left side. The veins of the abdominal wall were greatly distended (Fig. 36).

A plain radiograph of the abdomen showed that the diaphragm was raised on the right side. A large homogenous soft-tissue shadow filled the whole right abdomen and extended over to the left, the colon shadow being displaced to the left. An intravenous pyelogram showed a functioning left kidney; no dye appeared in the right kidney.

Blood-urea, 27 mg. per 100 c.c.

Blood-pressure, 115/47.

Blood-count :—

Erythrocytes	4,600,000	
Leucocytes	8,700	
Polynuclear neutrophils	32	per cent
Polynuclear eosinophils	3	" "
Small lymphocytes	27	" "
Large lymphocytes	29	" "
Large hyalines	7	" "

Hæmoglobin, 73 per cent

AT OPERATION.—Owing to an attack of scarlet fever, laparotomy was not performed until June 10. A very large moveable retroperitoneal tumour was

in the back and difficulty in walking. A tumour was present over the superior and lateral aspect of the left orbit, and there was marked proptosis of the eye (Fig. 39). Paresis of the lower limbs was evident.



FIG. 36.—Photograph before operation, showing distended abdomen and dilated veins.

The patient slowly and gradually went downhill, the proptosis increased, the lower limbs became completely paralysed, incontinence of urine and faeces was present, and she died on April 26, 1942.

AT AUTOPSY.—The post-mortem examination showed that the left orbit was filled with new growth which protruded into the cranial cavity. The brain was not invaded. A mass of new growth was seen in the region of the sixth and seventh dorsal vertebrae, and this had invaded the neural canal, compressing the cord. A recurrence, the size of a man's fist, was

1 2 3 4 5 6 7 8 9 10 11 12 13

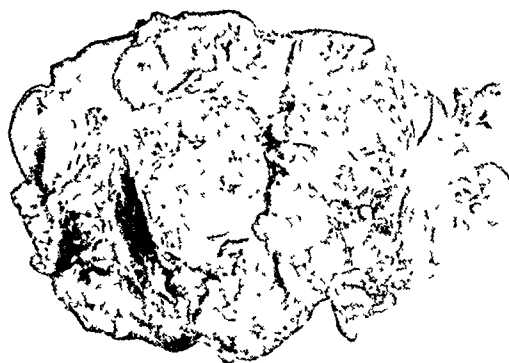


FIG. 37.—Photograph of the neuroblastoma.

displayed, with many engorged veins coursing over the surface. The tumour was not adherent except in the region of the right renal pedicle, and was removed together with the compressed kidney. The tumour weighed 7 lb. 12 oz. (Figs. 37, 38).

PROGRESS.—Convalescence was uneventful and the child was discharged from hospital on July 26. A course of deep X-ray therapy was subsequently given at the Middlesex Hospital. She was readmitted on Dec. 22 with one month's history of pains

1 2 3 4 5 6 7 8 9 10 11 12 13

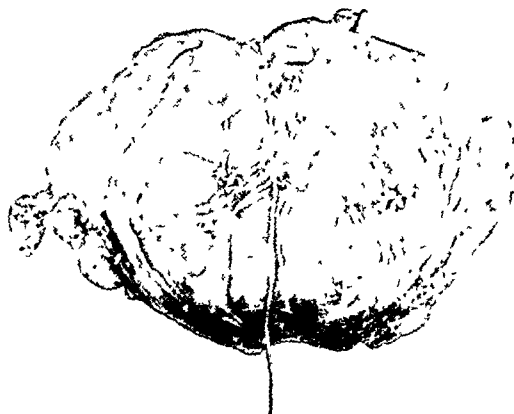


FIG. 38.—Photograph showing a probe in the ureter.

present at the site of the right kidney. A few secondaries were present in the diaphragm and in the liver.

HISTOLOGY.—The histological reports were of great interest. Dr. J. R. Gilmour, to whom I am greatly indebted for several communications, reported : "Portions of spindle- and polygonal-celled diffuse sarcoma from kidney; no epithelial or teratomatous tissue present. The appearance of the sarcoma is similar to that usually present in a teratoblastoma of the kidney, but in the absence of differentiation into

epithelium, and of muscle, the tumour cannot be regarded as a teratoblastoma or Wilm's tumour."

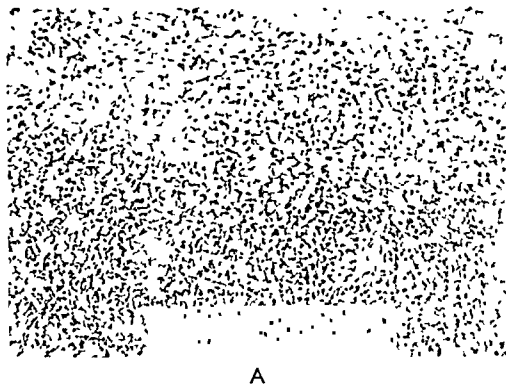
A later note stated that the cells were: "Polymorphic—stellate, flat, and spheroidal, variable density of cells with some areas poor in cells and rich in



FIG. 39.—Showing the orbital metastases and the proptosis of the eye.

collagen; tendency to form ill-defined spaces". He was of the opinion that the tumour was not a neuroblastoma.

Dr. H. A. Lucas also kindly examined the sections and reported: "The neoplasm is composed of cells which show only a moderate degree of differentiation.



A

FIG. 40—Microphotographs showing arrangement of cells. A,  $\times 60$  B,  $\times 150$ , C,  $\times 150$

the developing sympathetic system in the medulla of the suprarenal, and is probably of neuro-epithelial origin, the cells showing a slightly greater degree of differentiation than is present in some of the clinical types recorded. These neoplasms have been described under various names, neurocytoma seems to be the most appropriate."

Unfortunately, it was not possible to have the sections specially stained for neuro-fibrils.

## DISCUSSION

In the above case, and in many previously reported, some doubt has remained as to the correctness of the diagnosis, and an explanation may lie in the fact that various types of tumour arise from the adrenal gland. This can be shown by reference to the development of the gland. The adrenal cortex is of mesodermal origin and first appears in the early embryo as a ridge close to the Wolffian body. The cortex has an influence on the secondary sex characteristics, and in tumours of the cortex these are frequently profoundly altered. The medullary cells, on the other hand, arise from the ectoderm



B



C

They are not the round primitive type. Rosettes are present, stroma is very scanty, blood-vessels are chiefly of the small capillary type. A few cells show some resemblance to ganglion cells. The presence of nerve-fibrils is suggested in several areas, but were not clearly demonstrated in the stained sections examined. The neoplasm in my opinion arises from

of the primitive neural crest, and during the early growth of the embryo they become widely distributed throughout the sympathetic system, where they develop into sympathetic ganglia, Schwann cells, and chromaffin tissue. These primitive cells are rarely seen after the first few

weeks of intra-uterine life, but may be found in the adrenal medulla throughout foetal life, and may occasionally persist after birth. The fact that these cells undergo differentiation later than the other cells of the central nervous system may be a contributing factor in the frequent localization of tumours composed of primitive nerve-cells in the adrenal medulla. According to Potter (1942), sympathetic nerve-cells at the time of their migration from the neural crest are histologically similar to those of the central nervous system. They are small cells with hyperchromatic nuclei and scanty protoplasm, and tumours composed of such cells are neuroblastomas, or, more accurately, sympathogoniomas. In the normal process of development, the cells grow larger slightly vesicular nuclei and the cytoplasm increases in amount. The cells are now known as sympathicoblasts and tumours as sympathicoblastomas. The term 'neuroblastoma', as usually used, includes both types of tumours. In further development, the sympathicoblasts mature into chromaffin cells, ganglion cells, and Schwann cells, and tumours composed of these cells are known as pheochromocytomas, ganglioneuromas, and neurofibromas respectively. These tumours may all show a variegated picture owing to the different degrees of differentiation and to the varying relative proportions of cells and fibres which are present.

The neuroblastoma is therefore a highly malignant tumour of the sympathetic nervous system, being derived from the undifferentiated neuroblast. It may occur wherever the neuroblast is present, and is most common in the adrenal medulla, less frequent in the sympathetic ganglia, and, contrary to what one might expect, rare in the central nervous system.

The primary tumour is a soft nodular growth, usually well encapsulated, and shows a considerable variation in size. Growths as small as 1 cm. are reported as well as are large bulky tumours filling the greater part of the abdominal cavity. As the primary growth remains encapsulated, it does not usually spread to neighbouring organs, with the exception of the liver, which is invaded by direct spread through the bare area. The kidney is usually indented and compressed, but not often invaded. It might be expected that the tumour would destroy or compress the adrenal cortex, with the production of changes in the secondary sex characteristics, but, according to Broster et al. (1938), this is extremely rare. Smith (1932), however, reports a case which showed evidence of hirsutism and marked overgrowth of the eyelashes.

The primary growth is very liable to hæmorrhage and degeneration, which alters the original yellowish-grey colour of the tumour. Microscopically, it is composed of small round or oval cells with nuclei that resemble lymphocytes, and with very little cytoplasm. Interspersed between groups of the cells are ill-defined fibres which have been identified by special staining reactions

as axis cylinder processes and neuroglial fibres. Wright (1910) first described these fibrils, which tend to form longitudinal bundles or round masses surrounded by groups of neuroblasts forming the so-called rosettes. This rosette formation is found in one-third to one-half of the cases reported.

The neuroblastoma has a close resemblance to a round-celled sarcoma, and it is probable that many cases have been overlooked. Ewing states that it is necessary to include in this group most of the retroperitoneal round-celled sarcomas of infants, and many similar growths of the cervical, thoracic, and peripheral nervous systems.

Since the time of Pepper (1901) and Hutchison (1907), neuroblastomata have been classified into two clinical types, but it is now well known that there is an irregular type, and that the above classification does not always hold good. Wright's histological studies showed that the Pepper and Hutchison syndromes are just different manifestations of the same disease. The Pepper type is characterized by abdominal symptoms resulting from the primary growth and the metastases to the liver, while the Hutchison type is characterized by its distant metastases to the cranial bones. Frew (1911) endeavoured to explain this difference in the route and appearance of the secondary growths on the basis of the different lymph drainage of the two adrenal glands. The lymphatic vessels from the left adrenal communicate with the aortic chain of lymph-glands and cells from a left-sided growth may reach the thoracic duct and the cervical lymph-vessels and thence to the skull. The right adrenal is in direct contact with the bare area of the liver, to which the growth may spread by contiguity, while lymphatic paths along the inferior vena cava may carry the tumour to the pleura and lungs, which are not usually affected by left-sided growths. Frew's theory has not been found correct, and a review of the literature shows that the side on which the primary growth arises has little to do with the distribution of the metastases. In 56 Pepper-type cases, the primary growth was situated in the right gland in 27, in the left in 21, and in both in 8 cases. In 83 Hutchison-type cases, the primary growth was situated in the left gland in 38, in the right in 35, and in both in 10 cases. The Pepper type runs a more rapid course than the Hutchison type, indicating a more cellular growth and more rapid dissemination. As Chont (1941) points out, in all types of tumour, rapid and slowly-growing varieties occur, and metastases are seen long after cure at the primary site, indicating that these secondary growths remain dormant for some considerable time.

Neuroblastomas, therefore, probably give rise to distant metastases at a relatively early stage of their growth. In the rapidly growing Pepper type these distant metastases remain small, and death occurs before they reach such a size as to

influence the clinical picture. In the more slowly growing Hutchison type the distant metastases form one of the striking features of the disease. The clinical type, therefore, to which a case conforms may depend more on the rate of growth of the primary tumour than the side of the body in which it arises.

### CLINICAL FEATURES

Neuroblastoma is a disease of young children, but there are several recorded cases occurring in adults: Ballard (1940) reported 1 case in a man of 69, and Weichselbaum 1 in a man of 72. It is undoubtedly a rare condition, and Law (1932) reports that at the Paddington Green Children's Hospital only 4 cases occurred in twenty years, and at the Hospital for Sick Children, Great Ormond Street, only 6 cases occurred in six years. Tumours arising from organs other than the adrenal are still more rare. According to Boyd retinal tumours show a striking familial tendency, and there is a case on record where in a family of sixteen, ten children died of the disease.

While it is clinically convenient to retain the classical Pepper and Hutchison types, it must be recognized that this division is arbitrary, and that cases occur which cannot be placed in either group.

The Pepper type occurs in young children usually under 2 years, is of short duration, and terminates fatally in a few months. The characteristic feature is great distension of the abdomen, due partly to the primary growth, but mainly to the enormous enlargement of the liver which results from invasion by the malignant cells. Nausea and vomiting may occur, but ascites is not, as a rule, present.

The Hutchison type is seen in slightly older children, usually over 2 years of age, and runs a longer course. Frequently it is only recognized after the occurrence of metastases, which are usually seen first in the region of the orbit and skull and later in the vertebral column or long bones. While the primary growth may form a large tumour weighing several pounds, it frequently is very small and is only discovered at post-mortem examination. The most striking feature is the proptosis of one or both eyes due to the intra-orbital metastases, and in advanced cases the eye may be almost dislocated from the socket. Swelling and ecchymosis of the eyelids usually precede the proptosis. Movements of the eyeball, vision, and the pupil reflexes may be impaired, but not necessarily so, and papilloedema is present in advanced cases. Ulceration of the cornea may occur as a result of the eyelids being unable to close over the proptosed eye. Owing to the increased intracranial pressure, separation of the cranial sutures may occur, the coronal suture being most often affected.

In both clinical types the above features are accompanied in the later stages by pallor, wasting,

and listlessness, and an irregular temperature is common. Anaemia is very common, particularly in advanced cases of the Hutchison type. Painful swollen joints may simulate rheumatic fever, and tenderness over the metaphysal ends of the long bones may result from bone metastases. A leucocytosis may occur, but is not of marked degree. Both Law (1932) and Smith (1932) report the presence of subcutaneous nodules over the chest wall, anterior abdominal wall, and forearms, but these are distinctly rare and have not been reported by other observers.

### DIFFERENTIAL DIAGNOSIS

Neuroblastomas have to be distinguished from Wilms' tumours, and errors in diagnosis are more likely to occur in the irregular types of cases. The case here reported was thought to be a Wilms' embryoma prior to operation, but the subsequent progress led to the alteration in the diagnosis. Wilms' tumour usually occurs in children under 2; hæmaturia may occur, but by no means invariably. Bone metastases in Wilm's tumour are rare, but when they occur the pelvis is the most frequent site.

Ewing's sarcoma may also be a common source of error. Willis (1940) draws attention to the fact that the skeletal metastases in neuroblastoma may present all the clinical features of a Ewing's sarcoma. He describes two such cases and comes to the conclusion that the subject of Ewing's sarcoma is chaotic, that the occurrence of a primary growth of this nature is still unproved, and that metastatic growths of various types, particularly neuroblastoma, may be responsible for many of the cases of Ewing's sarcoma.

Tumours of the adrenal cortex are characterized by the changes in the secondary sex characteristics, and frequently by elevation of blood-pressure.

The osseous changes in leukaemia may closely resemble those of neuroblastoma, but repeated blood studies and sternal punctures will lead to the correct diagnosis.

In American literature, Chont (1941) and Wyatt and Farber (1941) have recently described the radiological appearances in a series of cases. There is no characteristic radiological picture, but in a small number of cases calcification has been seen in the primary tumour. The calcium deposits vary from fine uniform stippling to irregular confluent shading throughout the tumour mass. A pycelogram is no real aid to diagnosis, and its main function is to demonstrate the presence of the opposite kidney. It is impossible to tell whether the tumour arises within the kidney or from the adrenal, but it may show downward displacement of the kidney and ureter.

In cases with cranial metastases, the skull bones may show innumerable areas of destruction varying in size from pin-point to several millimetres in diameter. In some cases round areas of destruction are seen indistinguishable from

secondary carcinoma or sarcoma. The metastases to long bones are more characteristic and the striking feature is the frequency of bilateral symmetrical lesions. In the majority of cases, bone destruction and proliferation are seen in the form of small discrete lesions or confluent areas of destruction with a small amount of proliferation of surrounding bone. Massive destruction is usually seen at the metaphysis and pathological fracture may occur.

### TREATMENT

Treatment so far has proved extremely disappointing, and a fatal issue can be expected in one to ten months from the onset of symptoms. Extremely divergent views on treatment have been expressed, and some writers believe that surgery is harmful and radiotherapy not beneficial. Lehman (1932), however, reports a case alive and well fifteen years after operation, and, more recently, the response to radiotherapy has been such as to provide encouragement for further efforts in this direction. While the fatal issue has not been averted by radiotherapy, temporary disappearance of secondary deposits has been reported. Willis's case, thought to be an Ewing's sarcoma, was proved to be highly radiosensitive, and was effectively controlled by radiotherapy for over two years. The method of choice, therefore, would appear to be surgical removal of the primary tumour, with subsequent irradiation of the area involved.

### BIBLIOGRAPHY

- BALLARD, J. W. (1940), *Delaware St. med. J.*, **12**, No. 5, 86.  
 BOYD, W., *Surgical Pathology*, 660.  
 BROSTER, L. R., et al. (1938), *The Adrenal Cortex and Intersexuality*, 181. London: Chapman & Hall.  
 CHONT, L. R. (1941), *Amer. J. Roentgenol.*, **46**, No. 6, 809.  
 CLARK, W. C. (1939), *Arch. Ophthalmol.*, **22**, No. 4, 575.  
 FARBER, S. (1941), *New Engl. J. Med.*, **225**, No. 13, 510.  
 FREW, R. S. (1911), *Quart. J. Med.*, **4**, 123.  
 GREENTHAL, R. M. (1939), *Arch. Pediat.*, **56**, No. 9, 561.  
 HUTCHISON, R. (1907), *Quart. J. Med.*, **1**, 33.  
 KROHN, S. E., and KENNEDY, W. J. (1938), *J. Urol.*, **40**, No. 3, 359.  
 LAW, F. W. (1932), *Lancet*, **2**, 1101.  
 LEHMAN, E. P. (1932), *Ann. Surg.*, **95**, 473.  
 LUCAS, P. J. (1940), *Med. Times, N.Y.*, **68**, No. 9, 411.  
 MALISOFF, S. (1939), *J. Urol.*, **41**, No. 3, 296.  
 PARSONS, P. B., and PLATT, L. (1940), *Amer. J. Roentgenol.*, **44**, No. 2, 175.  
 PEPPER, W. (1901), *Amer. J. med. Sci.*, **121**, 287.  
 POTTER, E., and PARRISH, J. M. (1942), *Amer. J. Pathol.*, **18**, No. 1, 141.  
 REDMAN, J. L., et al. (1938), *Amer. J. Dis. Child.*, **56**, No. 5, 1097.  
 SMITH, J. (1932), *Lancet*, **2**, 1214.  
 WEBSTER, R. (1939), *Med. J. Aust.*, **1**, No. 5, 193.  
 WILLIS, R. A. (1940), *Amer. J. Pathol.*, **16**, 317.  
 WRIGHT, J. H. (1910), *J. exp. Med.*, **12**, 556.  
 WYATT, G. M., and FARBER, S. (1941), *Amer. J. Roentgenol.*, **46**, No. 4, 485.

## LOCAL SULPHANILAMIDE TREATMENT OF FRESH WOUNDS IN COMPLETE PLASTERS

By JEAN ORR-EWING, J. C. SCOTT, F. H. MASINA, J. TRUETA,  
AND A. D. GARDNER

FROM THE SIR WILLIAM DUNN SCHOOL OF PATHOLOGY, UNIVERSITY OF OXFORD

THIS investigation aimed at obtaining incontrovertible evidence about the effect of local sulphanilamide on the bacteriological condition of compound fractures and other severe wounds treated by thorough cleaning and excision, followed by enclosure in plaster; and at correlating this with the clinical results.

Frequent and complete observations were made on 32 patients, of whom 18 received local sulphanilamide and 14 did not. None had general chemotherapeutic treatment.

At first all cases were sulphanilamide-treated, as we believed we had a satisfactory control series, not so treated, which had been investigated in the previous year; but after a time we realized the unsoundness of the principle, as experience and organization had steadily improved the surgical results apart from sulphanilamide treatment. In the latter part, therefore, we treated contemporary series of cases with and without

local sulphanilamide, attempting to avoid any 'selection' that might vitiate our conclusions. This attempt was, on the whole, successful. Although the two groups could not be absolutely uniform in severity and delay before treatment, the balance in both respects is weighted against the sulphanilamide group. In the latter, the interval between wounding and operation ranged from 2½ hours to 10 hours; in the 'untreated' controls from 1 hour to 5½ hours, the average being 5 hours in the former and 4 hours in the latter. The 'treated' group, moreover, contains a rather larger proportion of gravely injured patients. The complete sulphanilamide series includes the 10 cases which were sulphanilamide treated in the previous year, without strictly contemporary controls. Any subsequent deterioration of clinical treatment would have invalidated the comparison, but we are certain that no such change occurred. Nevertheless, the smaller,



fully controlled series, excluding the 10 cases, has been separately analysed, and shows a significant bacteriological superiority of the sulphanilamide group in the second week, when the scanty bacteria left after the operation have had full time to develop.

Bacteriological examinations were made by cultivating all tissue excised at the primary operation, by taking swabs at changes of plaster, and at other times by swabbing through special

at the outset, and in all 4 it persisted throughout the period of observation.

*Staphylococcus aureus* was found in 23 out of the 32 wounds. Its numbers were lower in the sulphanilamide-treated wounds, but the frequency with which it disappeared after sulphanilamide was only slightly greater than in the controls. In the great majority of both series it persisted throughout. Anaerobes were scarce and unimportant; the few *Cl. welchii* present in excised

Table I.—NUMBER OF WOUNDS SHOWING HIGH OR LOW DENSITY OF TOTAL BACTERIA AT DIFFERENT TIMES

COMPLETE SERIES									STRICTLY CONTEMPORARY SERIES			
Density of Flora	Days 3-7		Days 8-14		Days 15 to Plaster-change		Second Plaster Days 1-20		Days 3-7		Days 8-14	
	S	C	S	C	S	C	S	C	S	C	S	C
Low (0 to +)	14	5	13	1	7	2	3	6	6	5	6	1
High (+ to ++++)	2	8	3	11	6	8	2	6	2	8	2	11
$\chi^2_c$	5.618		11.812		1.483		2.387		1.388		6.676	
P (n = 1)	<0.02 >0.01		<0.001		<0.3 >0.2		0.2 >0.1		<0.3 >0.2		<0.01	
Statistical conclusion	Significant		Significant		Not significant		Not significant		Not significant		Significant	

S, Sulphanilamide; C, Control (no sulphanilamide).  
Note: Not all the wounds in each series were observed at every period.

'windows'. Direct microscopical examination of films from the swabs gave us a rough estimate of the degree and nature of the bacterial contamination, and of the cellular exudate. Complete bacteriological analyses were made each time as described in the *British Medical Journal*, (1941, 1, 877), with certain additions, such as para-aminobenzoic acid blood-agar. The amount of bacterial growth on direct platings was noted, and this, combined with density of the bacterial population in the films, is expressed in Table I by the number of plus signs. Statistical analysis shows that the total bacteria in the sulphanilamide-treated wounds are significantly less than in the controls during the first 14 days after a single application of the drug. After 14 days the difference is not significant.

Regarding individual bacterial species: Haemolytic streptococci were found in 6 sulphanilamide-treated wounds at the operation, and 5 of these disappeared as the result of operation and sulphanilamide treatment, while 1 persisted. Of the control wounds, 4 showed this organism

tissues failed to reappear in both series. Gram-negative rods, proteus, *Ps. pyocyanea*, etc., were unaffected. Assessment of the amount of inflammatory exudate from the macroscopical and microscopical examination of the swabs, though more difficult than that of the bacteria, showed a statistically significant reduction in the sulphanilamide series in the second week (during the first week there was hardly any in either group).

The clinical results in both series were uniformly good, and no evidence was obtained that the local sulphanilamide affected the clinical progress of the cases.

Thus we have demonstrated a selective reduction of the wound flora by sulphanilamide, but we have not established a corresponding clinical effect.

(Full details of the work, of which this article is a résumé, with discussion and references, may be obtained from the Medical Research Council, to whom we are indebted for financial support. Our thanks are also due to Mr. P. H. Leslie and Professor M. Greenwood for statistical help.)

## MINIATURE SCAR-CARCINOMA OF THE LUNG AND THE "UPPER SULCUS TUMOUR" OF PANCOAST

BY ILLTYD JAMES AND WALTER PAGEL

FROM THE DEPARTMENTS OF SURGERY AND PATHOLOGY, CENTRAL MIDDLESEX COUNTY HOSPITAL,  
ACTON LANE, N.W.10

IN recent years considerable attention has been focused on a group of tumours arising in the neighbourhood of the apex of the lung. Pancoast (1924, 1932) suggested for this group the term 'superior pulmonary sulcus tumour', because they presented certain features which differentiated them from other tumours in this region: (a) The tumours were localized in the superior thoracic inlet; (b) They were malignant and the histological picture was that of a squamous-celled carcinoma; (c) They produced symptoms and signs by invasion of neighbouring structures—the brachial plexus, causing pain referred to the upper limb, with wasting of the muscles, and the sympathetic, producing a Horner's syndrome on the affected side; (d) The tumours are independent of the lung and pleura and other structures in the neighbourhood, and there is no evidence of a primary focus elsewhere. For this reason Pancoast suggested an origin from branchial rests.

The clinical features of this group are certainly well defined, but the site of origin is still a matter for discussion. For this reason the details of two cases recently under our care are presented. Although the clinical picture of spinal cord compression was unusual, the other features were characteristic. The investigations appear to throw light on some of the controversial points associated with this group of neoplasms.

### CASE REPORTS

**Case 1.**—G. S., a man aged 60, had complained of intermittent pain between the upper part of the shoulder-blades for thirteen months. This had become more intense during the five months preceding admission to hospital, but he was able to work until five weeks before, when the pain became too severe. Three weeks before admission his legs began to get weak, and within three days he was unable to walk. During this period he had noticed 'pins and needles' in his legs. For a week before admission he could not pass urine and was catheterized twice daily. He had been incontinent of faeces. During the last month he had lost weight and had become short of breath.

**ON EXAMINATION.**—There was a moderate amount of wasting, a flaccid paraplegia, and a complete sensory loss up to the level of the third thoracic segment. A Horner's syndrome was present on the right side. No other abnormality could be found in a careful general examination. Radiographs of the chest revealed an opacity of small size in the superior mediastinum to the right of the first and second dorsal vertebrae, but radiographs of the spine showed no involvement of the bodies of the vertebrae, the intervertebral foramina, or the ribs. Lumbar puncture yielded clear, colourless cerebrospinal fluid at a pressure of 160 mm. Pressure on the jugular veins showed an incomplete

block. The fluid contained 2 lymphocytes per c.mm., and 500 mg. of protein. The Wassermann reaction was negative. Cisternal injection of lipiodol showed a complete block at the level of the first thoracic vertebra.

**AT OPERATION.**—Laminectomy of the upper thoracic vertebrae revealed a firm, pinkish, extradural tumour 'en plaque' surrounding the dura mater at



FIG. 41.—Case 1. Apex of the right lung with pleural cap (arrow) and emphysematous bullae in the subapical lung tissue.

the level of the second and third thoracic vertebrae. The tumour was closely adherent to the dura. The latter was opened and was found to be thickened in places to nearly  $\frac{1}{4}$  in. by tumour tissue. The cord at the level of the first thoracic vertebra was dumb-bell-shaped from compression. No intradural extension was found. A frozen section was made and this revealed a squamous-celled carcinoma with frank prickly cells embedded in much fibrous stroma. Tumour tissue was removed to free the cord and the dura was left open. Closure of the wound was made in layers.

He was not improved by the operation, and died one month later from bronchopneumonia and pyelonephritis.

AT AUTOPSY (P.M., 1943/167).—The right apex was found adherent to the pleural dome; it was, however, easily separated without loss of substance (Fig. 41). The apex of the lung showed a typical

scarred area with much anthracotic pigment was found. It was about  $3 \times 3$  mm. in size. In its centre (Fig. 43, M) there were a moderate number of distended alveolar spaces, some of them with elastic septa.



FIG. 42.—Case 1. Flat subpleural nodules (arrows) in the right pleural dome.

'pleural cap', with a little induration but no gross, naked-eye evidence of a neoplasm. In the pleural dome on its inner aspect, however, there was a growth consisting of two flat subpleural nodules, measuring together  $3 \times 3$  cm. in diameter (Fig. 42), fixed to the inner ends of the second and third ribs, and extending by continuity into the body of the second and third thoracic vertebrae, the former being compressed into a wedge. In this region the tumour had infiltrated the dura mater of the cord constricting it, without, however, involving the substance of the cord. Meticulous dissection of the whole bronchial system and careful examination of the extrapulmonary organs, including pharynx, œsophagus, brain, bones, and suprarenals, failed to reveal any evidence of growth, primary or metastatic. Death was due to necrotizing cystitis and pyelitis with multiple abscess formation in both kidneys.

#### HISTOLOGICAL EXAMINATION.—

The growth in the right pleural dome exhibited the same structure as that seen in the biopsy sections. There were strands and sheets of squamous and prickly cells and also alveoli with horn pearls in the centre. In some areas stroma was abundant, in others scarce.

The apex of the left lung which had been slightly adherent to the growth was examined in a complete series of sections. It consisted of:—

a. A typical, hard, fibrotic, almost structureless pleural cap, devoid of elastic fibres (Fig. 43, C).

b. A circular band of fibrotic apical lung tissue containing many curly elastic fibres, obviously the remnants of collapsed and compressed lung alveoli (Fig. 43, B).

The pleural cap and the fibrotic apical tissue were clearly separated by the thickened, deep elastic membrane of the pleura.

c. Between the pleural cap and the circular band of fibrotic and elastic tissue an almost homogeneous

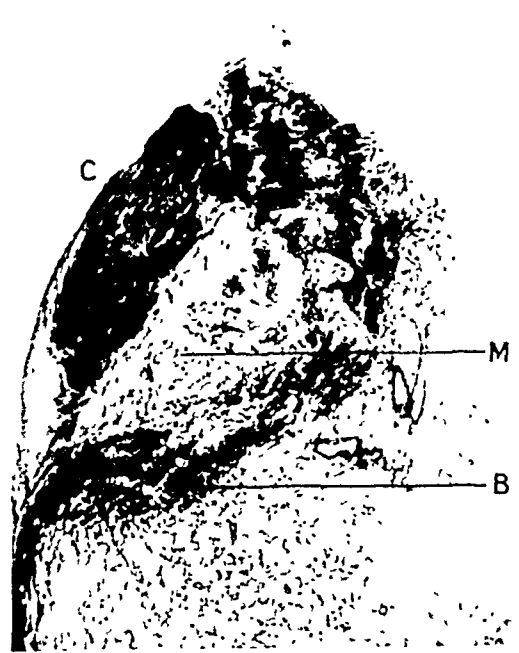


FIG. 43.—Case 1. Survey of histological section through right apex. C, Pleural cap; M, Focus of miniature carcinoma with 'sebaceous' material in distended alveolar spaces; B, Circular band of fibrotic elastic lung tissues. Weigert's stain for elastic fibres; counterstained with safranin. ( $\times 66$ .)

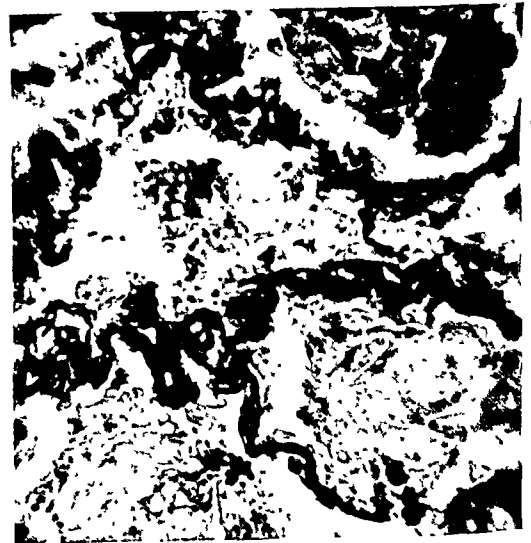


FIG. 44.—Case 1. Miniature carcinoma. Distended alveoli filled with flat 'horny' cells. Weigert's elastic stain. ( $\times 165$ .)

These spaces were filled with 'sebaceous' material, i.e., desquamated, flat, 'horny' cells, some with, others without, nuclear remnants (Fig. 44). Some of these sebaceous plugs were surrounded by seams of

squamous or prickly cells (*Fig. 45*). There were also a few horn pearls. Towards the periphery of this area the 'sebaceous' material was seen to disappear gradually. On both sides some slender, compressed-looking strands of prickly cells, and in the marginal areas larger units of such elements, emerged (*Fig. 46*).

**Comment.**—Meticulous post-mortem examination of the bronchial tree, the lungs, and extrapulmonary organs failed to detect a growth primary to the tumour in the pleural dome. This was a prickly-celled (squamous-celled) carcinoma with hornification. It was marked out by its tendency to invade the bony structures of the inlet of the chest. It had caused a 'Pancoast' syndrome—although this was complicated by the signs of spinal-cord compression. Thus a genuine instance of 'tumour of Pancoast' seemed to lie before us.

Serial sectioning of the lung apex, however, revealed between a thick 'pleural cap' and a circular band of compressed and thickened lung tissue the presence of tumour-cell units situated in an anthracotic scar. Its centre was occupied by alveoli with elastic septa containing 'sebaceous' material surrounded by bands and strands of squamous cells. On both sides, towards the periphery, these cellular units became more solid, and the 'sebaceous' alveoli disappeared. The origin of the tumour in the pleural dome and the problem of the 'Pancoast tumour' at large obviously rests with the interpretation of these findings in the apex of the lung. For this was certainly involved, although only detected microscopically. Three questions presented themselves: (1) What is the relationship between the apical scar and the cancer-cell units? (2) Can evidence be adduced of a secondary invasion of the apical lung tissue from the growth in the pleural dome? (3) Are similar changes in pulmonary scars known without growth in the pleural dome? In

indurative changes found so often in this region as a sequela of tuberculous infection or to the accumulation of dust. They far exceeded in extent and intensity the involvement of the area by carcinoma, and

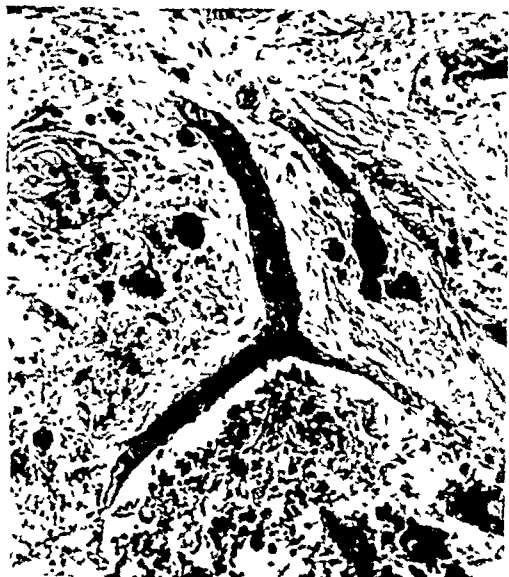


*FIG. 46.*—Case 1. Miniature carcinoma. Marginal parts. Units of prickly cells (P), with intercellular bridges. ( $\times 135$ .)

from the thickness and hyaline nature of the fibrous tissue the impression was derived that they antedated the growth. The presence of the apical scar is, therefore, no evidence against an extrapulmonary origin of the growth.

2. If the growth was extrapulmonary in origin it must have invaded the dense tissue of the apical scar and found the way to its centre. Invasion of thick fibrous structures is possible, as shown by a few carcinomatous units seen in the outer marginal parts of the very dense fibrotic pleural cap. Against this interpretation, however, is the very central position of the 'sebaceous alveoli' in the apical scar. These show the most advanced horn production, i.e., conversion into sebaceous masses with only occasional preserved epithelial units. Deposition of sebaceous material was seen in these areas alone. We have, therefore, the most advanced hornification, i.e., the oldest changes in the centre of the apical scar, from which on both sides carcinomatous cell units radiate out towards the periphery.

3. Similar changes to those described independent of pleural or pulmonary carcinoma are known. They were placed on record under various headings, such as "Unusual proliferation of atypical and heterotopic epithelium in bronchiectasis" (Pagel, 1926, whose article should be consulted for further references), and "A microscopic focus of oat-cell carcinoma in a bronchiectatic lung" (Stewart and Allison, 1943), etc. These occur in pulmonary scars, notably those due to bronchiectasis. In other words, there exists a 'miniature carcinoma' which may either be detected accidentally, or may have formed the transitional stage between the metaplastic changes found commonly in bronchial epithelium of dilated bronchi and bronchial carcinoma. As a rule, these miniature carcinomata consist of a group of alveoli situated in dense fibrotic scar tissue and filled with oblong 'basal cells' which are rich in chromatin. In Pagel's observation there were, in addition, typical prickly



*FIG. 45.*—Case 1. Miniature carcinoma. Sebaceous plug, surrounded by seam of squamous cells. Hematoxylin and eosin. ( $\times 66$ .)

other words, could their interpretation as a lesion antedating that in the pleural dome be justified?

1. The pleural cap as well as the apical scar is identical in all histological detail with the ordinary

cells and cucumber-shaped masses of homogeneous material, giving all the histological appearances of hornification.

In the present case the oldest changes consisted, therefore, of a focus of epithelium with advanced hornification situated in the centre of an apical scar. Bronchiolar ectasis due to collapse induration and fibrotic shrinking of apical lung tissue led to metaplastic changes, i.e., the formation of squamous-cell nests and 'sebaceous' material. These may have been present for a long time and might have been discovered accidentally had death occurred from another disease at an earlier date. In this case, however, the sebaceous cell-nests had the chance to develop malignant properties. Their unusual situation may explain the unusual course: instead of invading the lung tissue below the dense fibrotic scar, they radiated out to the periphery between scar and pleural cap, and involved the pleural dome and by continuity the bony structures on the inner aspect of the pleural dome.

While the investigations of this case were fresh in our minds another case with a picture of spinal-cord compression presented itself. The clinical picture and the radiological evidence was so similar to the previous case that a diagnosis of the cause of compression could be confidently made.

**Case 2.**—J. N., a man aged 62, had complained of intermittent pain in the left side of the chest at the level of the third rib for about eleven months. This pain would shoot from the shoulder-blade to the front of the chest and down the inner side of the arm to the elbow. Although the pain gradually increased in severity, he was able to carry on with his work until he developed weakness of both legs six weeks



FIG. 47.—Case 2. Lipiodol block at the level of 3rd thoracic vertebra. Opacity to left of upper thoracic vertebrae.

before admission. Within three weeks he had lost the use of his legs completely. Two weeks before admission he could not pass urine and he had to be catheterized. His previous history was free from incident. There was no history of a cough.

**ON EXAMINATION.**—He was an emaciated man in poor general condition owing to infection from cystitis and pressure sores. He had a spastic paraplegia with flexor spasm and loss to all forms of

sensation up to the level of the fourth thoracic segment. No Horner's syndrome was present. He was tender over the third thoracic spinous process. Radiograph of the chest revealed a small, oval opacity in the superior mediastinum to the left of the third



FIG. 48.—Case 2. Soft subpleural growth (arrows) in proximity to 3rd and 4th thoracic vertebrae.

thoracic vertebra (Fig. 47). Radiography of the spine showed pitting of the left transverse process of the third thoracic vertebra and a little irregularity in the left side of the body.

Lumbar puncture revealed clear cerebrospinal fluid under normal pressure. A partial block was demonstrated on compressing the jugular veins. The cerebrospinal fluid contained 100 mg. of protein per cmm., and 6 lymphocytes; the Wassermann reaction was negative. Intrathecal injection of 1 c.c. of lipiodol revealed a block at the level of the third thoracic vertebra (Fig. 47).

A diagnosis of cord compression by carcinomatous spread from the apex of the lung was made. No operation was performed. The patient went rapidly downhill and died 2 weeks after admission from bronchopneumonia and pyelonephritis.

**AT AUTOPSY (P.M., 1943/224).**—Almost lobar fibrinous, partly hæmorrhagic, consolidation of the right upper lobe was found. The left upper lobe and the upper parts of the left lower lobe were firmly adherent to the chest wall, notably in the medial parts adjoining the necks of the third and fourth ribs. Here a fairly soft subpleural growth 3 cm.  $\times$  3 cm. in diameter was detected in close proximity to the third and fourth thoracic vertebrae, which had been invaded by it (Fig. 48). The dura mater was surrounded at the level of the third and fourth vertebrae by tumour tissue, which had invaded the spinal canal through the intervertebral foramina. The spinal cord was not invaded, but was constricted by the thickened dura. There was extensive purulent pyelonephritis. Careful dissection of the lungs, the bronchial system, the pharynx, the œsophagus, and the rest of the organs failed to reveal any evidence of a primary growth.

**HISTOLOGICAL EXAMINATION.**—The consolidated parts of the right upper lobe showed simple inflammatory changes (confluent bronchopneumonia). A section through the subpleural growth in the third intercostal space showed a large-celled carcinoma with alveolar pattern. In some of the alveoli the cells are of the 'crazy-pavement' type, with intercellular spaces and bridges—a prickle-celled carcinoma. There was, however, no hornification (Fig. 49)

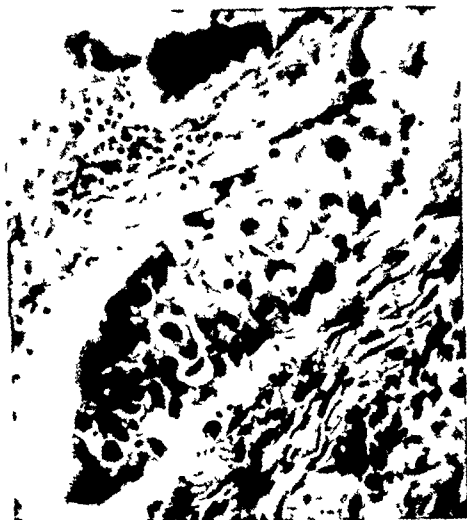


FIG 49.—Case 2 Section through the subpleural growth. Squamous-celled carcinoma No hornification ( $\times 100$ )

The relationship of the growth to the lung was examined in serial sections through various areas of the upper and medial parts of the left upper lobe adherent to the parietal pleura covering the growth. In the parts of the lung adherent to the tumour only an area of dense anthracotic scar tissue with a calcified round focus in the centre contained tumour-cell units (Fig. 50). On both sides of the scar symmetrical infiltration was found with nests and alveoli of prickle cells, and it was in these areas alone that hornification could be detected (Fig. 51).

**Comment.**—This case again presents an apparently extrapulmonary prickle-celled carcinoma invading the necks of the ribs, the vertebræ, and spinal canal. This time, however, the growth developed below the pleural dome. The parts of the lung adherent to the growth were free except one area of an old anthracotic scar with a calcified centre. This isolated involvement of an area of scar tissue seems to be more than accidental. Moreover, it was only in this part of the growth that hornification was seen, i.e., changes indicating tissue maturity and absence of anaplasia. It is fair to assume that these areas represent the original site of the growth.

The isolated involvement of a pulmonary scar and the presence of the presumably oldest changes therein are features which this case has in common with the first, and which provide evidence that the tumour originally developed in and around an intrapulmonary scar and not outside the lung.

## DISCUSSION

The two cases fall into the group described by Pancoast as "superior pulmonary sulcus tumours", for they exhibit most of the familiar

characteristics of these tumours—viz., a primary squamous-celled carcinoma situated in the apical part of the pleural cavity, extending into the bony structures of the pleural dome, notably the ribs and vertebræ, and in this process invading the brachial plexus and the sympathetic trunk, producing pain and paresis in the shoulder and the arm together with a Horner's syndrome.



FIG 50.—Case 2 Survey through scar tissue in the lung adherent to subpleural growth. Diffuse infiltration of scar tissue with squamous-celled carcinoma. In the centre of scar a black calcified nodule ( $\times 20$ )

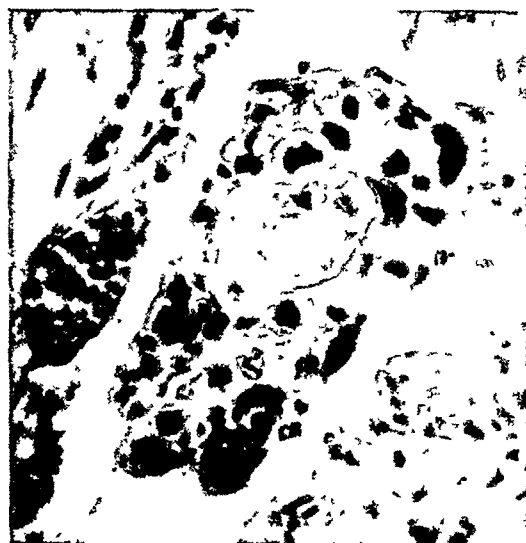


FIG 51.—Case 2 Scar carcinoma of lung adjacent to subpleural growth showing nests of squamous cells with central hornification ( $\times 165$ )

Although Pancoast suggested these criteria, only 2 of the 7 cases described by him were subjected to histological examination, and only one of these showed the picture of a squamous-celled carcinoma. There are indeed but few cases in the literature conforming to these

criteria. Clarke (1934) described 1 case with an extrapleural tumour eroding the ribs and vertebral bodies adjacent to the apex of the lung. A Horner's syndrome with pain in the arms and muscular atrophy was present. Although the tumour was adherent to the lung, there was no evidence of a pulmonary origin. In the absence of a bronchogenic source, Clarke suggested an origin in a branchial remnant. Fried (1935) described 2 cases presenting all the characteristics of a Pancoast tumour. In each case histology showed a squamous-celled carcinoma with no evidence of a pleural or pulmonary origin. In one case the lung was adherent to the tumour and was detached from it with difficulty, although apparently separated from the tumour by the pleura. Fried is of the same opinion as Pancoast and Clarke—that these tumours arise from remnants of the branchial clefts, and he suggested the term 'branchioma' as descriptive of their origin. Graef and Steinberg (1936) recorded 1 case with a typical Pancoast syndrome. The lung was adherent to the apical tumour, but was easily separated without loss of lung substance. The histological structure was that of a squamous epithelioma, and they considered it was not possible to rule out a branchiogenic origin.

Morris and Harken (1940), in a complete review of the subject, described 3 cases which conform to the criteria laid down. They concluded from their study that there does exist at the superior pulmonary apex an epithelial neoplasm which is distinguished from all other tumours common to this region by its lack of origin from any known adjacent tissue or from metastatic foci, and by a histological picture suggestive of an embryonal source.

In all these cases no detailed microscopical investigation by serial sections of the part of the lung underlying the tumour has been made, and therefore the hypothesis of an extrapulmonary origin advanced by these various authors cannot be upheld.

It is difficult to say whether the two cases described by us provide sufficient evidence against the existence of a true extrapulmonary "upper sulcus tumour". We would submit, however, that it is no sufficient to state that the

lung and the growth were easily separable "without loss of substance", or that it was "definitely extrapleural", or that there was "infiltration of the apical pleura with freedom of the bronchi and lung tissue". Careful examination of serial sections of the adjacent parts of the lungs is essential before an extrapulmonary origin can be postulated. Although the evidence produced in the two cases described by us indicates an intrapulmonary origin, the tumours form an unusual group presenting characteristic clinical, radiological, and histological features. We agree, therefore, with Pancoast that they deserve to be more widely known as a special entity, and we suggest that 'miniature scar-carcinoma of the lung with involvement of the thoracic inlet' is more descriptive of the pathology than the more general term 'superior pulmonary sulcus tumour'.

### SUMMARY AND CONCLUSIONS

Two cases are described in which the Pancoast syndrome was present in association with a tumour at the thoracic inlet. There was no macroscopical evidence of a pulmonary origin.

Serial sections of the lung tissue adjacent to the tumours revealed a miniature scar-carcinoma. This showed the oldest changes—hornification and sebaceous material—and was therefore regarded as the origin of the growth.

Serial sections of the adjacent lung tissue are necessary before a pulmonary origin of the 'upper sulcus tumour' can be excluded.

The authors wish to acknowledge their indebtedness to Mr. James E. Mayhew and Mr. Harry F. Pegler for technical assistance.

### REFERENCES

- CLARKE, B. E. (1934), *Amer. J. Path.*, **10**, 693.  
 FRIED, B. M. (1935), *Amer. J. Cancer*, **25**, 738.  
 GRAEF, I., and STEINBERG, I. (1936), *Amer. J. Roentgenol.* **36**, 293.  
 MORRIS, J. H., and HARKEN, D. E. (1940), *Ann. Surg.*, **112**, 1.  
 PAGEL, W. (1926), *Virchows Arch.*, **262**, 583.  
 PANCOAST, H. K. (1924), *J. Amer. med. Ass.*, **83**, 1407.  
 — — (1932), *Ibid.*, **99**, 1391.  
 STEWART, M. J., and ALLISON, P. R. (1943), *J. Path. Bact.*, **55**, 105.

## ADRENAL VIRILISM

### REPORT OF A CASE WITH UNUSUAL FEATURES

By N. G. B. McLEITCHIE, LIEUT. R.A.M.C.

FORMERLY LECTURER ON PATHOLOGY, GLASGOW UNIVERSITY, AND ASSISTANT PATHOLOGIST, WESTERN INFIRMARY, GLASGOW

THE problem of the development of abnormal sexual characteristics is complex. The case described here is more complex than usual. Many of the findings are capable of some explanation; the unexplained touch on many problems.

### CASE REPORT

HISTORY.—The patient was born in 1903. From birth until puberty the patient appeared, behaved, and was brought up as a normal female child. There were other brothers and sisters of the family who were normal, but cannot now be traced.

1917: At the age of 13-14 years hair began to grow on the face and the voice broke. Menstruation did not start, although it was noted that the external genitalia had developed normally for the age. The general bodily habitus, voice, and facies became so distinctly male in type by the age of 16 years that the patient then changed her Christian name to 'John', donned male attire, left home, and worked, first as a van-boy, and later as a lorry driver.

1925: At the age of 22 years the patient returned to his parents' home suffering from neurasthenia. (The masculine pronoun will now be used when referring to the patient.) The trouble appeared to have developed after a doctor had been called in to treat the patient for influenza and his true condition had become known. Later the family doctor sent the patient to Western Infirmary, Glasgow, for observation in Professor Ralph Stockman's wards. The following are the notes from the ward journal, additional to the family doctor's letter giving the previous history and affirming that the patient had never menstruated.

"Condition: Neurasthenia secondary to virilism. Pyorrhœa alveolaris. The patient is 4 ft. 11 in. in height and superficially appears to be a man. He lies comfortably in bed so long as his head is supported, but whenever his head is raised from the pillow he closes his eyes and complains of lightheadedness amounting almost to fainting. The breath is very foul, due to a general condition of pyorrhœa. The distribution of hair is male, the beard being abnormally strong. (The patient shaves every second day.) The cranial hair is receding and is of very fine texture. The hands and feet are small and suggest femininity. The external genitalia are apparently of typical female form. Figure and voice masculine; pelvis masculine; gestures and mental outlook suggest femininity. June 5: Chloroform. Dr. Martin examined the genitalia. The clitoris has not the normal female shape, but is notched like the male penis. The urethra is of female shape and position. Vagina present with rudimentary cervix, but no definite uterus. Gland palpable in position of right ovary. No signs of testes. "Complete extraction of teeth was performed at same occasion."

The patient was discharged a few weeks later, his general condition having improved. He left his parents' home shortly afterwards.

1935: The patient was again traced. He was working as a lorry driver and was apparently accepted as a male without any suspicion by his workmates.

1941: The patient returned to the family doctor for a certificate to support his claim as a 'conscientious objector'. He had been working since the outbreak of war as a shipyard labourer. On being interrogated (1943) his fellow workmen and friends at his lodging gave no indication that they even suspected his being abnormal. If he had any psychological upset he managed to keep it hidden. He had no interest in the female sex. The certificate given to him by his family doctor gave the additional information that the patient now menstruated, but the date of commencement was not given.

1943: After a history of a few months' duration of lower abdominal discomfort, ultimately with alternate diarrhœa and constipation, sudden acute illness supervened and the patient was admitted to the Western Infirmary, Glasgow, as an 'acute abdomen'. The doctor who sent the patient to the infirmary had noted that there was a carcinoma of the right breast, which the patient stated had been present for two years.

Laparotomy was performed a few hours after admission to hospital and pus was evacuated from the pelvis. A sloughing mass of tumour in connexion with an ovarian dermoid cyst was found by the surgeon. The patient died a few hours after the operation. Autopsy was performed twelve hours later.

The only additional information obtained from the patient at hospital was the statement that he had menstruated all his life. This must be taken with reserve as the patient was *in extremis*. There is post-mortem evidence that the patient did menstruate, and it is known that he menstruated in 1941. It must be presumed, therefore, that the patient started to menstruate some time after 1925, when he was examined in the Western Infirmary.

#### POST-MORTEM EXAMINATION.—

*External Appearances.*—Apart from the external genitalia and breasts, the subject had the facies and bodily habitus of a male of rather slender build and of small stature (5 ft. 1 in.). There was little subcutaneous fat and the body and limbs presented an athletic appearance. The hair of the head was of fine texture. There was complete baldness of the frontal area, and a heavy growth of coarse, recently shaved hair on the shaving areas of the face; hair growth was not marked on the chest or limbs. The abdominal and genital hair were of female distribution. The breasts appeared as unusually circumscribed elevated plaques about 8 cm. in diameter and 2.5 cm. thick. The nipples were prominent and showed no displacement. *The right breast* had a uniform hard consistence. *The left breast* was less hard and had the characteristic knobby consistence of fibrocystic mastopathy. Both breasts were very easily removed by blunt dissection and traction. Section of the right breast revealed a uniform dense white, hard, fibrous tissue; section of the left breast showed similar appearances, but with numerous small cysts throughout. No axillary glands or other evidence of lymphatic tumour spread from the breasts were present.

*Thorax and Abdomen.*—There were large quantities of pus in the peritoneal cavity, especially in the pelvic region. The coils of the small intestine were glued together by light fibrinous adhesions.

*The heart*, 230 g.; *liver*, 1000 g.; *spleen*, 90 g., were slightly smaller than one would expect in a male, even allowing for the build and stature of the subject. *The kidneys* weighed 120 g. each. No abnormality was detected in the cardiovascular, urinary, skeletal, or alimentary systems, except for tumour invasion of the colon, which will be referred to later. The lungs showed congestion and œdema.

*The thyroid* (15 g.) showed natural tissue. No thymic tissue was noted in the mediastinum.

*The liver*: Eight white nodules, from milinary size up to 2 cm. in diameter, having the typical appearances of secondary carcinoma were present in the liver.

*The right adrenal gland* (18 g., 3 cm.  $\times$  3.5 cm.) was represented by a body with four roughly triangular surfaces. The bulk of the specimen was taken up by a hard mass of calcareous and ossified material replacing the medulla. The flat surfaces of the hard mass were clothed by a thick fibrous capsule containing small islets of bright yellow adrenocortical tissue. At the free edges the fibrous capsule was reflected off to form an integument for thickened ridges of adrenal cortex. (Fig. 52.)

*The left adrenal gland* (5.5 g.) presented natural appearances; the cortical tissue was prominent, but not definitely increased.



**Para-aortic glands:** In the region of the celiac axis there was a conglomerate mass of enlarged glands, from 0.5 to 2 cm. in diameter, irregular in shape, fibrous, and containing many chalky white calcareous nodes.

**The ovaries:** Both ovaries were represented by dermoid cysts filling the pelvis, the right 11 cm. in diameter, the left 8 cm. These consisted of cavities

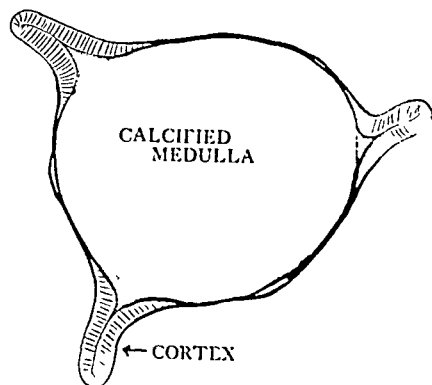


FIG. 52.—Diagram of section of right adrenal body.

filled with hair and inspissated sebaceous material, with smooth thin walls. In each there was an area of thickening in the wall incorporating ovarian tissue. In the right dermoid the ovarian tissue was extensive, and contained numerous blood-vessels, small cysts containing clear fluid, and a large corpus luteum stretched over an area of 3.5 cm. in diameter and 0.5 cm. in maximum thickness. In the left cyst the

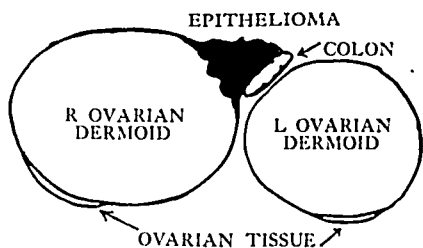


FIG. 53.—Diagram of ovarian dermoids.

ovarian tissue was confined to an attenuated area 2 cm. in diameter and presenting as white ovarian stroma without other macroscopical detail. Postero-internally the interior of the right cyst was heaped up and irregular. From here a large mass of pale tumour tissue extended backwards and inwards to invade the wall of the colon at the brim of the pelvis. Numerous yellow areas of necrosis were present in the tumour mass and, near the colon, there was sloughing of large areas with loculi of pus in the tissues. This was evidently the source of the peritonitis. (Fig. 53.)

**The uterus,** 5 cm. long from neck to fundus and 2.5 cm. in maximal thickness, was small, but had a thick layer of endometrium (Fig. 54). The cervix was small.

**Head:** The brain (1050 g.) showed a general atrophy, with widening of the sulci and ventricles and excess of cerebrospinal fluid. No other abnormality was detected. The pineal body and the pituitary gland were of natural size and appearance.

#### HISTOLOGICAL EXAMINATION.—

**The Adrenal Glands and Calcified Para-aortic Glands.**—The adrenal glands and the calcified para-aortic glands require joint consideration as they present associated abnormalities.

The capsules of the para-aortic glands show fibrous thickening with lobulation by thick fibrous trabeculae. The calcified areas, of amorphous appearance, are in some cases completely invested by fibrous tissue, in others associated with uncalcified caseous material. The whole presents a picture indistinguishable from effete tuberculosis (see Fig. 57). While the regressive

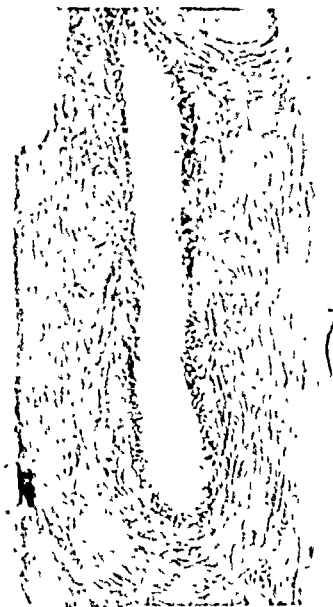


FIG. 54.—Transverse section of uterus. Note the thick endometrium. H. and E. (x 3.)

changes are in most areas complete, a few small cellular follicles with central caseation, indistinguishable from tuberculous follicles, are present. Although tubercle bacilli have not been demonstrated, it is considered that it must be taken that all the latter appearances represent tuberculosis with almost complete healing. The same process appears to be a reasonable explanation for the large calcified and bony mass taking up the right adrenal medulla. The picture is the same, except that no cellular follicles are present and there is much imperfect bone formation in the calcified amorphous material. There is no organoid differentiation to indicate the existence either of a simple tumour of bone or of degeneration in a bone-bearing teratoma. The flat surfaces of the bony mass in the right adrenal are clothed by a thick fibrous capsule including small pseudo-adenomatous formations of adrenocortical epithelium. The thickened tissue reflected off at the angles of the right adrenal body (Fig. 55) presents the general gross characters of adrenal cortex and shows all three histological zones. But, scattered throughout, are collections of altered adrenocortical epithelium. In some of these pseudo-adenomatous masses the cells are large and show gross vacuolation; in others they have a solid non-vacuolated cytoplasm (Fig. 56). The left adrenal gland shows no abnormality.

Nodules of epithelial tissue are present in the conglomerate mass of calcified coeliac glands. They are encapsulated by fibrous bands. The cells are arranged in columns supported by loose stroma, with

the malignant epithelium in the right breast and the hepatic metastases, the cells of the latter being smaller and having vesicular, oval nuclei and scanty, loose, pale-staining cytoplasm. The fuchsinophil granules



FIG. 55.—Section of part of right adrenal, showing thickened ridge of adrenal cortex and the calcified and ossified medulla. H. and E. ( $\times 1.5$ .)



FIG. 56.—Cortex of right adrenal. Note the disturbance in architecture. H. and E. ( $\times 30$ .)

small focal accumulations of lymphocytes in places. They are polygonal and have dense eosinophil cytoplasm which, with the oil-immersion lens, can be seen to be finely granular. The nuclei are central, and hyperchromatic. No mitoses are present. (Figs. 57, 58.) This epithelium is sharply distinguished from



FIG. 57.—Para-aortic gland, showing node of calcified effete tuberculosis on left and foci of epithelial tissue (dark masses) circumscribed by fibrous capsules (white rings). H. and E. ( $\times 4$ .)

of Vines (referred to in the discussion) were not found in the coeliac epithelium or in the adrenal cortex.

*Ovarian dermoids*: The cyst walls consist of thin epidermis with hair follicles and accessory skin glands.

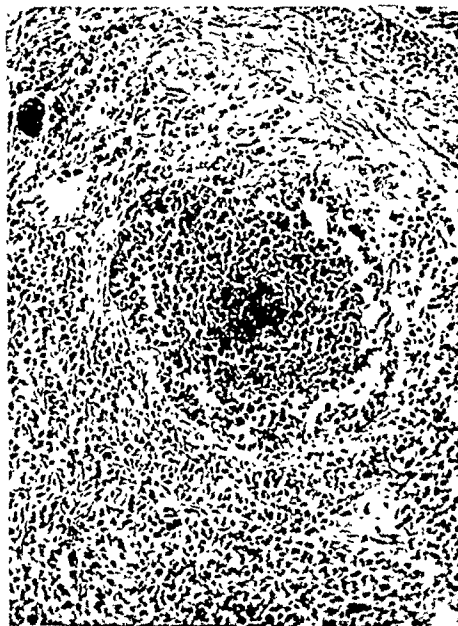


FIG. 58.—Area from Fig. 57, showing adrenocortical epithelium in loose columns and in whorl encircling lymphocytes. H. and E. ( $\times 115$ .)

A few small islets of cartilage are the only other elements found on extensive examination. The mass of tumour arising in the heaped-up area in the right cyst wall and extending in a large mass into the colon is a squamous epithelioma; it is well differentiated,

with large cell-nests having prominent keratinized centres. While well differentiated in mass, the basal cells are large and aberrant. The tumour extends through the wall of the colon to the basement membrane

in the wall of the right cyst equals a normal ovary in amount, while that of the left is slightly less. Examples of primordial follicles, early follicle formation, a few small corpora albicantia, and many small



FIG. 59.—Epithelioma invading muscular coat of colon. H. and E. ( $\times 115$ .)



FIG. 61.—Right breast showing malignant infiltration of dense fibrous stroma and also duct epithelial hyperplasia. H. and E. ( $\times 12$ .)

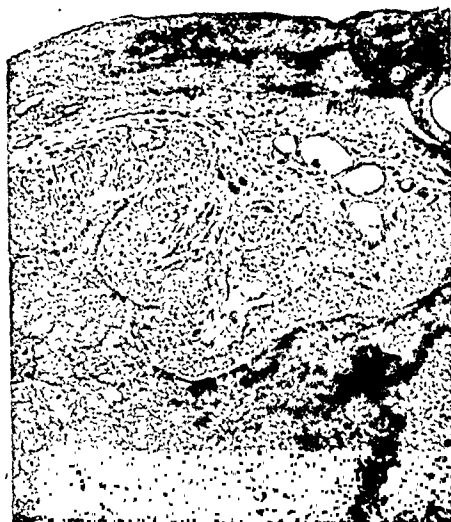


FIG. 60.—Part of large corpus luteum, right ovary; note the well-defined layer of luteal cells. H. and E. ( $\times 75$ .)



FIG. 62.—Left breast, showing dense stroma and epithelial hyperplasia in cystic ducts. H. and E. ( $\times 12$ .)

of the mucosa (Fig. 59). The infiltrated bowel musculature and the region of the colon above show hypertrophy, a degree of chronic obstruction apparently having been present. The ovarian tissue incorporated

atretic follicles have all been recognized in addition to the large macroscopic corpus luteum previously referred to (Fig. 60).

*Uterus:* A well-circumscribed intramural fibroid

takes up the whole thickness of the uterine wall at one point. The endometrium shows normal premenstrual secretory characters.

**Mammary glands:** Both breasts show dense hyaline fibrosis. The basement membranes of many of the ducts and acini show hyaline thickening and also peripheral whorled fibrosis. In some of the ducts and acini this obliterative process has resulted in destruction of the epithelium. In others there is epithelial hyperplasia with the production of intraduct and intra-acinar tumour of both solid and cribriform type. In the right breast the intraduct tumour has broken through, with the production of universal injection of the tissue spaces with tumour cells (Fig. 61), but there is only marginal infiltration of the surrounding fatty tissue. Cystic change in ducts and acini is conspicuous in the left breast. This is associated with many areas of intraduct tumour, but there has been no break through with the development of frank malignancy (Fig. 62).

The **hepatic tumour nodules** show characters consistent with metastases from the right breast. The tumour epithelium consists of small cells with loose scanty cytoplasm. The epithelium, associated with moderate stroma production, shows a tendency to adenomatous formation. The growing edge presents the characters of tumour invasion and there is no suggestion that the masses represent ectopic or metastatic adrenocortical epithelium.

The **pituitary gland** was examined by methods previously described (McLetchie, 1944, a). The gland shows a normal gross structure; the pars intermedia is represented by a single cleft. The basophils of the anterior lobe are not numerous but are within normal limits in relative proportion. The basophils show normal granularity, vacuolation is inconspicuous, and the hyaline lesion of Croke is absent. The acidophils and chromophobes present no abnormality.

Much of the **pineal** is calcified; no abnormality is detected.

**SUMMARY OF POST-MORTEM FINDINGS.**—Spare virile habitus with facial hair of male type; female external genitalia and enlarged clitoris; mammary carcinoma with hepatic metastases; bilateral ovarian dermoid cysts; epithelioma arising in right ovarian dermoid invading colon, with production of peritonitis; ovarian tissue, including a large corpus luteum, in wall of dermoids; right adrenal represented by ridges of thickened cortex upon a calcified and ossified medulla; epithelial tissue incorporated in mass of calcified coeliac glands; small uterus with thick endometrium.

## DISCUSSION

**The Adrenal Abnormality.**—The association of the development of virilism in the female with adrenocortical abnormality has long been known. The subject has been extensively studied and reviewed by Broster and Vines and their co-workers (1938). The case described is a good example of the condition. Here there was the development of the voice, bodily habitus, and facial hair distribution of the male, and enlargement of the clitoris, in an apparently normal female subject. The changes were so marked that within a few years of their first appearance the patient masqueraded successfully as a male, and later survived the 'rough and tumble' of a Clyde shipyard without incident. The alterations began at puberty. Broster and Vines describe

how marked sex-reversal may be when the alterations occur early in life, whereas, if occurring later, due to the loss of plasticity of the tissues, the changes are not so marked.

Broster and Vines describe numerous cases with adrenocortical hyperplasia. In the present case the adrenocortical abnormality is of some complexity. The right adrenocortical tissue is certainly thickened, but it is considered that the anatomical peculiarity of the specimen suggests that, in the beginning, there was a uniform thickening of the adrenal cortex, and that later the medulla was replaced and expanded by a morbid process resulting in atrophy of much of the cortex and leaving only the peculiar heaped-up projections of cortical tissue. But this is not an end to the adrenocortical abnormality. It is considered that the epithelial nodes embedded in the effete tuberculous mass in the coeliac region represent ectopic adrenocortical tissue. The tissue bears a close resemblance to an adenoma of ectopic adrenal tissue associated with virilism previously encountered. I find no evidence that it is a metastatic tumour. The ovarian tumour is an epithelioma; the breast cancer has different cytological characters from the coeliac tissues. In extensive sectioning no evidence of malignant tissue has been found in the coeliac lymphatics. The coeliac epithelium, well circumscribed by fibrous and calcareous tissue, has evidently been long resident there and shows, rather than invasive characters, retrogression before an advancing fibrotic process.

Thus, from its character and arrangement, it is considered that the coeliac epithelium is ectopic and not metastatic and that it is ectopic adrenocortical tissue. Moreover, it has been previously more extensive, and has been reduced by a chronic tuberculous process in neighbouring glands. The nature of the morbid process which has occupied and expanded the right adrenal medulla is more obscure. There is no evidence to indicate the existence of a bone-bearing teratomatous mass. It is considered that a now effete tuberculous process is the most reasonable explanation. But this is in dispute, and, in view of the other anomalies of development present, degeneration in some congenital malformation cannot be excluded as an explanation for the adrenal medullary mass. Either way the general argument remains—namely, that in the right adrenal a thickened adrenal cortex has been reduced by the evolution of a chronic process in the medulla and that in the coeliac region ectopic adrenocortical tissue has been reduced by a chronic process more obviously tuberculous in origin.

Ectopic adrenocortical tissue is not unknown in adrenal virilism. McLetchie and Scott (1944) have described an adrenocortical tumour in the tail of the pancreas associated with bilateral adrenocortical hyperplasia, and Kolodny (1934) has also described a case of virilism with a carcinoma of ectopic adrenocortical tissue in the coeliac region.

Vines (1938) has claimed that the essential abnormality in adrenal virilism is the presence of fuchsinophil granules in the adrenocortical epithelium. He relates these granules to a special androgenic activity of the adrenals which is normally dormant in adult life, but is long persistent in the male foetus and only transient in the female foetus. Vines used a special staining technique on fresh adrenal tissue. Difficulty had been found in obtaining selective differentiation with Vines' stain, and in applying the stain to post-mortem tissues. Nevertheless, in a previous case (McLetchie and Scott, 1944), granules as fuchsinophil as fibrin were found in adrenal tissue (hyperplastic cortex and cortical tumour), while such granules have never been found in tumours from other sources using the same staining technique—McFarlane's picro-mallory (McFarlane, 1944). In the present case the tissues had the additional handicap of requiring decalcification, and although no granules were found, Vines' hypothesis can only be adequately assessed on the examination of fresh tissue. Varying results have been reported by other workers, and the present position is obscure.

Grollman (1936) has attempted to relate the activity of the adrenals in virilism to the function of a special "androgenic" zone distinct from the cortex proper. In the mouse at certain stages there is a prominent zone of epithelium—the juxta-medullary or X-zone—between the medulla and cortex proper, which has different characters from the cortex. A similar zone is present in the human foetus, and Grollman claims that virilism in the female follows from a resurrection of this tissue. No illustrations of the hyperplastic adrenals of virilism have been published showing more than a thickened cortex proper, and I have found no evidence of the existence of such a zone in the adult human or in cases of adrenal virilism. Furthermore, some virilizing adrenal tumours show a striking resemblance to true adrenal cortex. In tumour production de-differentiation is the rule, and it would be a contradiction of our general knowledge of tumours to assume that such growths arose from a tissue having different characters from the cortex proper. Grollman also claims that Vines' granules are an attribute of the special juxta-medullary tissue. Vines' granules have only been described in the cells of the cortex proper and not in a new zone. In the present case zones of altered character are present in the thickened adrenal cortex. These are not constant in virilism and in this case they are more probably related to the presence of the medullary mass, with attendant alterations in vascular supply to the cortex, rather than morbid manifestations of a special altered function. It is considered that present evidence does not allow of more than the assumption that the thickened adrenal cortex of virilism is an attribute of simple hyperfunction. This may, however, be to the exclusion of certain functions of the adrenal cortex. Thus the adrenal cortex has a high ascorbic acid content,

and also has appreciable quantities of other vitamins. One of the most constant early signs of adrenal virilism is severe facial acne vulgaris. This may be due to the loss of that function of the adrenal cortex related to vitamins.

**The Ovarian Tissue.**—It should be noted that a gynaecologist palpated a "gland" in the right ovarian region, when the patient was twenty-one. Presumably this was the right ovarian dermoid. At autopsy the patient had abundant ovarian tissue in the wall of the right dermoid, and it cannot be postulated that the presence of the dermoids interfered with the hormonal function of the ovaries. The dermoid cysts can thus only be regarded as part of a complex congenital anomaly not specially related to the virilizing process.

**The Development of Menstruation.**—The development of menstruation in so complete a case of virilism presents a problem in itself. Precise knowledge of the history is not as complete as one would have wished. Nevertheless, it is clear that from puberty until the age of 22 the subject did not menstruate and that, at the end of that period, a gynaecologist reported that the cervix was rudimentary and that there was no definite uterus. From the patient's statements it would appear that menstruation had been present for many of his subsequent eighteen years of life. This seems more plausible on consideration of the autopsy findings of a small but by no means rudimentary uterus, complete with a thick layer of secretory endometrium (and a fibroid), while there is a large corpus luteum in the right ovary. I consider that the establishment of menstruation, the growth of the uterus, and the presence of a large corpus luteum in the ovary at autopsy have been brought about by reduction of the adrenal tissue, cortical and ectopic, by the chronic obliterative processes referred to. The obliterative process is of old standing, and this is consistent with the establishment of menstruation many years ago.

Though it is presumed that a reduction of the excessive adrenocortical tissue was sufficient to allow of the establishment of menstruation, this did not permit of a reassertion of other feminine characters. It is considered that this is mainly due to loss of plasticity of the tissues with age and indicates the hopelessness of surgical intervention once these abnormal conditions are long developed.

**The Two Malignant Tumours.**—The presence of two undoubtedly malignant tumours is rare. In the present case there is in a subject of 40 years a scirrhous carcinoma of the right breast and an epithelioma arising in the wall of an ovarian dermoid of otherwise simple structure. In both cases malignancy is undoubted; the epithelioma having produced a large mass of tumour with invasion of the colon; while in the right breast there is widespread scirrhous carcinoma associated with hepatic metastases presumably blood-borne. At present sex hormones, especially the oestrogens, are playing a prominent

part in the production of experimental cancer in general and of experimental mammary cancer in particular. There can be no doubt that the patient had a very abnormal endocrine make-up and it is attractive to suggest that this hormonal upset was an important factor in the development of the two malignant growths. At the present time the assay of hormones in the human subject is in an embryonic stage and there has been little correlation of the empirical data so far obtained with physiological and pathological phenomena. Nevertheless, the presence of two malignant tumours in a subject with undoubted endocrine upset may at least serve as a stimulus to the pursuit of knowledge in the field of endocrine assay in the human subject, with applications far beyond the study of rarities such as the case described. In regard to this question many senior surgeons will recall the practice of ovariectomy in association with mastectomy for breast cancer.

### PROBLEMS OF DIAGNOSIS AND TREATMENT

Broster and Vines (1938), Walters, Wilder, and Kepler (1934), and others have reported successful amelioration of the condition of virilism by removal of the larger adrenal in cases of adrenocortical hyperplasia, and of adrenocortical tumours when present. Intervention must be as early as possible, and, indeed, is inadvisable when the condition is of long standing, as is obvious in the present case, where reduction of the offending tissue has made the patient's condition worse by initiating menstruation.

In the event of laparotomy the surgeon must be aware that the offending tissue may lie outside the adrenal glands proper. In the present case there is ectopic tissue in the region of the celiac axis, and I have already cited cases with adrenal rest tumours in the pancreas and in the celiac region. Glynn (1911) quotes a number of cases of the allied condition of pseudo-hermaphroditism with large adrenocortical rests in the broad ligament. It must also be remembered that the rarer arrhenoblastoma group of ovarian tumours produces a syndrome indistinguishable from adrenal virilism. It is to be noted that claims have been made that certain virilizing tumours of the ovary arise in ectopic adrenocortical tissue (Novak, 1941).

A recent paper by Anderson, Hain, and Patterson (1943) indicates that early diagnosis of the adrenal abnormality associated with virilism may be made with the finding of high pregnanediol and 17-ketosteroid values in the urine and they recommend that these estimations be made in all cases of secondary amenorrhœa to ensure the early diagnosis of such cases.

While early diagnosis of the condition of virilism is advisable, if surgical intervention is going to be of any avail, it must be recognized that in its early history Cushing's syndrome is indistinguishable from adrenal virilism, and

accordingly the intelligent management of these cases requires an understanding of the morbid basis of Cushing's syndrome.

### CUSHING'S SYNDROME

In 1932 Harvey Cushing described the multi-glandular syndrome of pituitary basophilism which now bears his name. The syndrome was associated with the development of obesity, sometimes painful and sparing the limbs, hypertension, and vasculo-cutaneous alteration, with the development of characteristic striæ, glycosuria, hyperglycæmia, osteoporosis, and polycythæmia, and in the female with amenorrhœa and hirsutism of male type. This contrasts with the condition of virilism as exemplified by the present case, where there was maintained a spare virile habitus without the development of obesity or other signs of multiglandular disease. Nevertheless, Cushing's syndrome takes time to develop and in its early history there may be no more than amenorrhœa, slight roughening of the features, and slight hypertrichosis. Such a case has been reported by McLetchie and Scott (1944), where, after a history of amenorrhœa and hypertrichosis, the patient, a woman of 25, died in coma. At autopsy, in addition to an adrenal carcinoma, such gross alterations were found in the basophils of the hypophysis that it left no doubt that, had the patient lived longer, there would ultimately have been declared a fully developed Cushing's syndrome.

Cushing attributed the syndrome to a basophil adenoma of the anterior pituitary, though he also stated that he believed that the syndrome could equally well be produced by an adrenocortical tumour. Later the precise pathological definition of the condition became obscured, in that cases of clinically undoubted Cushing's syndrome were described with a bewildering array of findings; thus we have the basophil adenoma of the hypophysis, and in one case a metastasizing carcinoma of the basophils; adrenocortical adenoma and more commonly carcinoma; and cases of thymic tumour. It is to be noted that these lesions are not unconnected, in that the basophil adenoma is usually associated with frank adrenocortical hyperplasia; the adrenocortical carcinoma sometimes with basophilia (relative increase in the basophils), and the thymic tumour with adrenocortical hyperplasia. However, in addition to the above pathological types, there were added cases with no tumour anywhere and (it was claimed) a normal hypophysis on serial sectioning, and also cases with small chromophobe or 'indeterminate' adenomata in the anterior pituitary (Cohen and Dible, 1936; McLetchie, 1944, b; Cameron, 1940; Freyberg, Barker, Newburgh, and Collier, 1936). In 1935 Crooke showed that whatever the pathological type there was a constant and special abnormality of the basophil cells of the hypophysis, namely, the replacement of the granular cytoplasm of the basophils to a varying degree by a refractile hyaline cytoplasm. Basophil

hyalinization was a rare and inconspicuous finding in conditions other than Cushing's syndrome. Crooke's findings have been verified and conspicuous basophil hyalinization described in a case where there was no endocrine tumour (McLetchie, 1944, b). Crooke maintained that since basophil hyalinization was associated with a normal nucleus, the lesion represented the anatomical basis of an abnormal function of the basophils which was the essential abnormality of Cushing's syndrome. This well-substantiated hypothesis was highly acceptable on general grounds, since it united an otherwise varying pathology associated with a constant multiglandular symptomatology, in itself highly suggestive of a constant hypophysial abnormality. Moreover, Crooke's finding distinguished the syndrome pathologically from adrenal virilism, in that in the latter he did not find basophil hyalinization.

Later Severinghaus (1938) and others reported that basophil hyalinization in cases of Cushing's syndrome was commonly associated with nuclear breakdown of a curious character; ultimately, the nucleus appeared as a large blister taking up most of the cell and leaving only a fine peripheral rind of hyaline cytoplasm. Despite this gross nuclear change, cell dissolution was not described. It would appear that the American school favoured the view that hyalinization merely represented a process of cell death in the basophils and could not represent a special functional abnormality. Since then it has been shown that the appearances first noted by Severinghaus are produced by gross cytoplasmic vacuolation and that the nuclei are intact though they may be grossly compressed and scalloped by the multiple cytoplasmic vacuoles. Moreover, these appearances are inconstant in pituitary basophilism and sometimes not present even when basophil hyalinization is extreme (McLetchie, 1944, b).

On the basis of these and other findings a more unified conception of the pathology of Cushing's syndrome has been put forward; namely, that: (1) Cushing's syndrome is the attribute of hyperactivity of the basophil cells of the hypophysis and of the adrenal cortex, and (2) hyalinization of the basophil cells of the hypophysis is a manifestation of hyperfunction of these cells. Thus it is considered that the basophil adenoma, when present, is the primary anatomical abnormality, while the accompanying adrenocortical hyperactivity is commonly expressed in frank adrenocortical hyperplasia; the adrenocortical carcinoma produces basophil hyperfunction which is always expressed by hyalinization and sometimes also by relative increase of the basophils (basophilism). In the case of the thymic tumour the probable sequence of events is more obscure, but is correlated with the other types in that there is always basophil hyalinization (hyperactivity) and adrenocortical hyperplasia (hyperactivity); while in cases with no endocrine tumour it is assumed that there is

either generalized basophil hyperactivity (there is conspicuous basophil hyalinization) as a primary factor, or that the primary factor is adrenocortical hyperfunction (there is frequently adrenocortical hyperplasia). Small chromophobe adenomata and excessive vacuolation of the basophils in the hypophysis are regarded as secondary phenomena (McLetchie, 1944, b).

Since adrenal lesions unassociated with demonstrable pituitary change are associated with virilism, while, on the other hand, when associated with hyalinization of the basophils of the hypophysis Cushing's syndrome develops, it may be asked: "What determines the difference?" McLetchie (1944, b) has put forward the hypothesis that this may only be a question of degree, virilism being commonly associated with adrenal hyperplasia while adrenocortical tumour usually leads to the development of Cushing's syndrome. In other words, it may be that only a great degree of adrenocortical hyperfunction can stimulate a complementary basophil hyperfunction equivalent to a basophil adenoma. While Anderson, Hain, and Patterson (1943) have described a giant adrenal tumour associated with virilism, and proved at autopsy not to involve basophil hyalinization, this does not exclude the above theory, since most of the tumour was necrotic, quite apart from the general criticism that tumour tissue of endocrine origin varies greatly in its endocrine activity, and, therefore, size alone is not an absolute function of activity.

Thus in the assessment of any case of early masculinization, adrenal, hypophysial, thymic, and ovarian abnormality all require consideration. If a spare virile habitus has been maintained for some time, primary adrenal or ovarian abnormality is likely. If signs of multiglandular upset develop, e.g., obesity or glycosuria, an adrenal, thymic, or pituitary tumour is possible.

While there are admittedly great gaps in our knowledge of the interrelationship of the endocrine glands, the final elucidation of the problem must depend on many methods of approach and the surgeon has his part to play. He may do not more than perform laparotomy in a case of virilism, and remove an ovarian or adrenal tumour, to achieve a dramatic ameliorization of the condition. On the other hand, a thymic tumour may be found radiologically, and it remains to be seen what the result of the removal of such a tumour will be, for this has never been done. Indeed, the position of the thymus in the inter-endocrine relationships under discussion is the most obscure, and occupies a somewhat anomalous position. Clinically Cushing's syndrome is almost the exact opposite of Addison's disease. For this there is pathological correlation. The question of hyperfunction of the basophils of the hypophysis and of the adrenal cortex in Cushing's syndrome has already been mentioned; in Addison's disease the opposite obtains in that destruction of the adrenal cortex is accompanied by gross diminution of the basophil cells of the



hypophysis (Crooke and Russell, 1935). No apparent correlation exists in the case of the thymus, for in Cushing's syndrome there may be a thymic tumour, while in Addison's disease thymic hyperplasia is common.

It may be that on removal of the larger hyperplastic adrenal in what appears to be an early case of virilism the case will proceed to the development of a full Cushing's syndrome, and only autopsy will reveal the underlying cause—a basophil adenoma of the hypophysis—for it is not revealed radiologically. This type of case has been treated by insertion of radon seeds into the pituitary fossa (Pattison and Swan, 1938). It is possible that in the investigation of the urinary hormones of such a case means will be found of differentiating cases of primary pituitary and adrenal abnormality. All that and more remains to be seen.

Broster and Vines state that in some of their cases of virilism no endocrine gland abnormality was detected, though amelioration of symptoms may sometimes be obtained by removal of the larger adrenal. It should be appreciated that Broster and Vines' survey goes quite beyond the type of case which most surgeons will deal with, namely, the sudden appearance of progressive signs of virilism in a previously normal female. Here there is likely to be an obvious lesion. Equally well, the numerous factual abnormalities which have had to be mentioned in this assessment, will make it very obvious that in so complex a system abnormality productive of virilism may well arise more subtle than our present knowledge could elucidate. But if the ultimate analysis has to depend on a future development of the assay of hormones the basis of interpretation must rest on the correlation of hormonal assay in cases with a known lesion. This will only be arrived at by co-operation between the endocrinologist, the surgeon, and the morbid anatomist.

### SUMMARY

A case of virilism is described. The condition developed at puberty in an apparently normal female child. While male characteristics developed to a striking degree, the patient menstruated in the latter part of her life. Death occurred at the age of 40 years from peritonitis. At autopsy the following abnormalities were found: (1) The right adrenal cortex was thickened and there was ectopic adrenocortical tissue in the region of the coeliac axis; both tissues had been reduced by a chronic obliterative process. These were considered to be the essential abnormalities determining the condition of virilism, and their reduction the factor which allowed the development of menstruation, and explained the finding of a large corpus luteum in the right ovary and a

thick endometrium at autopsy despite the striking male facies and habitus. (2) Mammary carcinoma with hepatic metastases; bilateral ovarian dermoid cysts, epithelioma arising in the wall of the right dermoid and infiltrating the colon, with production of peritonitis. The problem of the interrelationship of all of these abnormalities is discussed. Attention is drawn to other conditions which may give rise to masculinization in the female.

It is a pleasure to record my thanks to my colleagues, Lt.-Col. Eric Gerstenberg, R.A.M.C., and Lt.-Col. W. L. Lamb, T.D., R.A.M.C., for criticism; to my former colleagues, Mr. Wm. Penny and Mr. Wm. Carson, of Glasgow University Pathology Department, for cutting some hundreds of sections at short notice; to my friend the late Mr. John Kirkpatrick for photomicrography; to Mr. J. Mill Renton, Western Infirmary, Glasgow, and Professor Ralph Stockman for permission to publish clinical details; to Dr. Gibson, of Old Kilpatrick, the patient's family doctor, for his interest and co-operation, and to Dr. Marion Gilmour for assistance at the autopsy.

### REFERENCES

- ANDERSON, A. F., HAIN, A. M., and PATTERSON, J. (1943), *J. Path. Bact.*, **55**, 341.  
 BROSTER, L. R., and VINES, H. W. C. (1938), *The Adrenal Cortex and Intersexuality*. London: Chapman & Hall.  
 CAMERON, A. T. (1940), *Recent Advances in Endocrinology*, 4th ed., 229 and 362. London: Churchill.  
 COHEN, H., and DIBLE, J. H. (1936), *Brain*, **59**, 395.  
 CROOKE, A. C. (1935), *J. Path. Bact.*, **41**, 339.  
 — and RUSSELL, D. S. (1935), *Ibid.*, **40**, 255.  
 CUSHING, H. (1932), *Bull. Johns Hopk. Hosp.*, **50**, 137.  
 FREYBERG, R. H., BARKER, P. S., NEWBURGH, L. H., and COLLIER, F. A. (1936), *Arch. intern. Med.*, **58**, 187.  
 GROLLMAN, A. (1936), *The Adrenals*, 57 and 339. London: Baillière, Tindall & Cox.  
 GLYNN, E. E. (1911), *Quart. J. Med.*, **5**, 157.  
 KOLODNY, A. (1934), *J. Amer. med. Ass.*, **102**, 925.  
 MCFARLANE, D. (1944), *Stain. Techn.*, **19**, 29.  
 MCLEITCHIE, N. G. B. (1944, a), *J. Endocrin.*, **3**, 323.  
 — (1944, b), *Ibid.*, **3**, 332.  
 — and SCOTT, L. D. W. (1944), *Ibid.*, **3**, 347.  
 NOVAK, E. (1941), *Gynaecological and Obstetrical Pathology*, 357. Philadelphia and London: Saunders.  
 PATTISON, A. R. D., and SWAN, W. G. A. (1938), *Lancet*, **1**, 1265.  
 SEVERINGHAUS, A. (1938), *The Anterior Pituitary Gland*, 84. Baltimore: Williams & Wilkins Co.  
 WALTERS, W., WILDER, R. M., and KEPLER, E. J. (1934), *Ann. Surg.*, **100**, 670.



## SHORT NOTES OF RARE OR OBSCURE CASES

## MAYDL'S HERNIA

By MILROY PAUL

PROFESSOR OF SURGERY, UNIVERSITY OF CAYLON

THE strangulation of a W-loop of bowel in a hernial sac, described by Maydl, is fortunately rare, for the prognosis is grave in this type of case. There are several factors which contribute to the gravity of the situation. The passage of four lengths of bowel side by side through the neck of the hernial sac determines a tight constriction, which often leads to gangrene of the bowel. The pressure of a strangulated loop of bowel in the general peritoneal cavity, viz., the middle segment of the W-loop, favours the onset of peritonitis. Moreover, the middle segment of the W-loop is usually long, and the release of the constricting ring is likely to be followed by the absorption of the contents of an unusually long stretch of strangulated bowel, an absorption which may give rise to a biochemical crisis of the first magnitude. In the case where the bowel is gangrenous and the loops long, the resection of so great a length of bowel will cause anxiety as to the subsequent powers of assimilation of the patient. For these reasons the record of a case of Maydl's hernia is likely to be of interest.

## CASE REPORT

**HISTORY.**—K. K. P. A., male Sinhalese, aged 30 years, was admitted to the General Hospital, Colombo, on Aug. 5, 1943, on account of a strangulated right inguinal hernia. The hernia had been noted for the past eight years; it had strangulated for the first time four years ago and an operation was performed for this at another hospital. The patient had left hospital in fourteen days, but the hernia had recurred in a month, and had been present since that time, although without trouble till the onset of the present strangulation twenty-four hours previously. The patient was in severe pain and a tense swelling reached all the way down the inguinal canal to the scrotum, indicating a strangulation at the internal ring. The temperature on admission was  $101^{\circ}$  F.

**OPERATION.**—An operation was performed under light percaïne spinal anaesthesia. An incision was made over the inguinal canal dividing the external oblique aponeurosis, and the hernial sac was opened. An offensive-smelling, blood-stained serum welled out, and a loop of flaccid, green small intestine was seen in the hernial sac. Behind this loop was a second loop of intestine, also in the hernial sac, which was plum coloured from congestion. The conjoint tendon was retracted and the fibrous ring at the neck of the hernial sac divided, releasing the strangulation. On delivery of the bowel, a long loop of flaccid, green small intestine was drawn out of the peritoneal cavity, and offensive-smelling brown serum flowed from the peritoneal cavity. The two loops of bowel in the hernial sac were continuous with the strangulated intraperitoneal loop and on delivery it was found that in all 5 ft. of bowel was involved—4 ft. 3 in. of

flaccid, green, gangrenous ileum, followed by 9 in. of plum-coloured ileum, terminating 4 in. from the ileocaecal valve. The caecum was exteriorized during this exploration. In view of the gangrene of the ileum, resection was inevitable, and 5 ft. of the bowel was resected, continuity being restored by end-to-end anastomosis, using a single layer of catgut which commenced with a Lee's suture at the mesenteric angle, continued as a through-and-through suture for the posterior wall of the anastomosis, and ran on as a continuous Connell suture for the anterior wall. By this arrangement of the sutures, sero-serous apposition was obtained on both anterior and posterior walls of the anastomosis (Fig. 63).

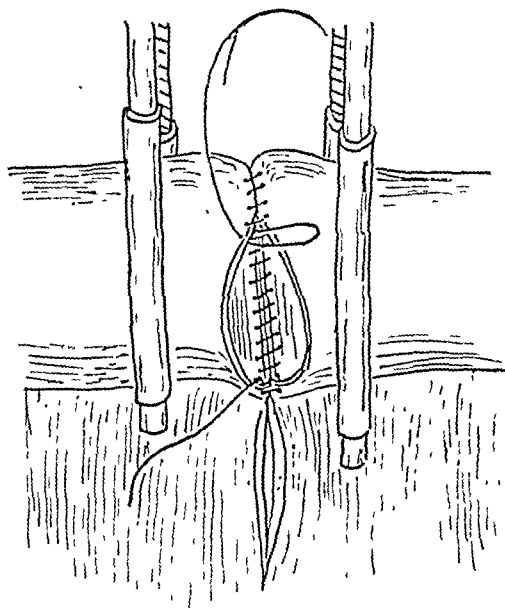


Fig. 63.—Shows method used for one-line suture of intestine, giving end-to-end anastomosis with sero-serous apposition front and back.

While this anastomosis was about to be performed the anaesthetist observed that the condition of the patient had suddenly deteriorated—his pulse, which had been of good volume, becoming rapid and thready. An infusion of normal saline was given intravenously, and two pints of saline were administered before the pulse became of full volume. From this time on, the pulse remained satisfactory. The hernia was repaired by the Wyllys Andrews method, using fine cotton thread sutures.

**POST-OPERATIVE PROGRESS.**—The patient made a good recovery from the operation, the wound healing by first intention. At the time the anastomosis was done some apprehension was felt at making an end-to-end anastomosis 3 in. from the ileocaecal valve, a site

noted for its poor vascular supply. However, no trouble was experienced from this. The pulse was 126 the next day, and the abdomen was moderately distended. The patient passed a stool spontaneously on the second post-operative day. Seven days after operation, he had bouts of severe colicky abdominal pain associated with a sense of peristalsis, but these ceased in three days. About this time the patient developed a diarrhoea which continued for twenty-one days. On recovery from this he passed one solid stool a day.

An X-ray examination after the administration of a barium meal was made a month after operation. The stomach was almost completely empty in two hours' time, and the barium meal had filled the

ascending colon and reached down to the lower end of the descending colon. In three hours' time the meal had left the stomach, jejunum, and upper ileum and was mainly in the colon.

*Examination of Stools* (Sept. 8): Total fats, 13.6 per cent; Split fat (free fatty acids and soaps), 11.8 per cent; Unsplit fat (neutral fat), 1.8 per cent.

The X-ray examination shows that there is rapid emptying of the stomach and small intestine. Nevertheless, the patient was passing only one solid stool a day, and the analysis of the fat content showed that the functions of absorption were normal. The resection of 5 ft. of ileum had no apparent ill effect on the patient and he left hospital a month after operation feeling fit and well.

## A CASE OF REVERSED ROTATION OF THE MID-GUT AND INTESTINAL OBSTRUCTION

BY MAXWELL ELLIS, WING COMMANDER, R.A.F.V.R.

CONGENITAL abnormalities resulting in unusual positions of the intestines are not uncommon, and a considerable amount of information has been accumulated about the causative dynamics as well as the clinical aftermath. Dott's (1923) description of the embryology is the classical exposition, and his beautiful illustrations clarify any faint obscurities that may be found in the text. The most rare of these abnormalities is reversed rotation of the mid-gut where the caudal portion of the loop of gut in the umbilical cord returns first into the general abdominal cavity and then rotates clockwise through 90°. The transverse colon comes to lie behind the superior mesenteric vessels, and thus behind the mesentery carrying the small intestine. In addition, the mesentery of the cæcum and ascending colon often fails to adhere to the posterior abdominal wall, and these organs then acquire an undue mobility. It is probable that this condition nearly always results in clinical mischief, as clinicians are responsible for the majority of the recorded cases. Gardner and Hart (1934) and Truesdale (1935) have collected 19 cases, and I have found 7 others in the literature (Donald, 1927; King, 1927; Doyle, 1937; Grant, 1940; Jessop, 1940; Holman, 1940; and Rose, 1941). Intestinal obstruction is the resulting lesion, due either to volvulus of the mobile cæcum and ascending colon, or to narrowing of the lumen of the transverse colon in its passage behind the small intestine mesentery. A further case of the latter type has recently been encountered.

### CASE REPORT

**HISTORY.**—An airman, aged 29, was admitted to an R.A.F. Station hospital on Oct. 7, 1942, with a history of an attack of diarrhoea seven days previously lasting for one night, together with abdominal pain. The pain persisted and he had been constipated for the four days before admission. He vomited on a number of occasions. A mild epidemic of enteritis was occurring at that time in the neighbourhood,

and he was admitted to the Infectious Diseases Hospital with a tentative diagnosis of infective enteritis. However, the constipation was not relieved, although he passed a little flatus, but his general condition remained good and free from any anxiety until Oct. 12, when he began to appear somewhat dehydrated. A soap enema produced a small amount of faeces, and he spent a good night, but on the following day the abdomen was slightly distended and a little tender on deep palpation. Constipation was absolute. That night he complained of a good deal of pain, and vomited some brownish fluid. When I saw him on Oct. 14 his tongue was dry and coated, and there was a faecal odour in his breath—the abdomen was very distended and tender all over. There was no visible peristalsis. His pulse-rate, which had been 80 to 90, was now 112, but the temperature, which had been swinging from 98° to 99°, had not risen. On searching questioning, the patient recalled that he had suffered from a number of similar, but much less acute, attacks in the past. None had lasted more than a day or two. A diagnosis of intestinal obstruction, probably due to volvulus, was made, and the abdomen was explored forthwith.

**AT OPERATION.**—A right lower paramedian incision was made. Much free turbid and blood-stained fluid was found in the peritoneal cavity, and there was very great distension of the small gut, cæcum, and ascending colon. The splenic flexure and the remainder of the colon distally were collapsed and pale. The great omentum, the splenic end of the transverse colon, and the stomach were all bound up in adhesions under the spleen. The ascending colon passed upwards deep to the small intestine mesentery at its root and entered the adhesions. The distal ileum, cæcum, and ascending colon were all unusually mobile, and it was at first thought that the condition was a volvulus of the whole of the small intestine and ascending colon. However, an attempt to rotate the bowel into a more normal position was found impossible, and a diagnosis of congenital malformation of the large gut (reversed rotation) was made. A cæcostomy was performed through an oblique stab wound in the right iliac fossa, and the paramedian wound sutured without drainage. Curiously enough, in spite of the handling of the intestines, the pulse-rate at the end of the operation was 104.

PROGRESS.—The immediate result was dramatic. The cæcum drained freely, and during the next afternoon the patient passed a copious liquid motion per

cæcostomy continued to drain well, and regular rectal motions were secured by small doses of liquid paraffin. By Oct. 28 the faeces were almost entirely being



FIG. 64.—Barium enema showing the redundant loop of colon beginning at the splenic flexure.



FIG. 65.—Barium enema. True lateral position with the patient erect, showing the transverse colon against the vertebral column.



FIG. 66.—The patient has moved from the position of Fig. 65 by flexing the trunk at the hips. Shows how the transverse colon and vertebral column move together, and loops of small intestine between the transverse colon and the anterior abdominal wall.

evacuated by the normal route, and very little drained from the cæcum. On Nov. 4, the patient started getting up, and a fortnight later an attempt was made to delineate the condition radiologically with the co-operation of Sq.-Leader J. Courtney. A barium enema was given which unexpectedly revealed a large redundant loop of colon in the splenic area. A true lateral view showed the transverse colon immediately anterior to the vertebral column. The patient was then made to flex the trunk at the hips, which would shift the transverse colon, if it were normal in position, forwards under the anterior abdominal wall. However, it did not move at all, and loops of small intestine were clearly seen between it and the anterior abdominal wall (Figs. 64-66). The barium enema was followed by somewhat unexpected complications. For one thing the barium caused almost complete obstruction, relieved with great difficulty by bowel wash-outs and liquid paraffin, and taking over a week to resolve. A mild form of enteritis then developed and the cæcostomy worked overtime, resulting in much excoriation of the surrounding skin, and all question of a further operation was postponed. But early in February, 1943, operative treatment again became possible.

SECOND OPERATION.—The patient was seen by Air-Commodore Stanford Cade, who explored the abdomen on Feb. 13. Some flimsy adhesions were present as a result of the previous operation, but otherwise the condition was exactly as then found. It was very clearly seen that at the level of the hepatic flexure the transverse colon disappeared into a tunnel behind the mesentery of the small intestine. It would have been quite impossible to excise that part

rectum. Some consolidation at the left base developed, but this cleared up very quickly and without incident on full doses of sulphathiazole. The

of the colon lying posterior to the small-intestine mesentery owing to the massive adhesions in the splenic region. It was also difficult to identify with certainty the most distal loop of ileum. Accordingly, the ascending colon immediately distal to the cæcum was anastomosed laterally to the sigmoid colon.

**PROGNOSIS.**—Again convalescence from the abdominal point of view was quite uneventful, and no chest complications developed. The rectum and cæcum both worked well, and the cæcostomy was closed on March 19. Thereafter the patient had no further bowel symptoms and passed a regular daily motion *per vias naturales*. He was discharged from hospital on April 22 fit and well and back to his normal weight. He was then on a normal diet. It was thought safer, and probably more in the patient's own interests, to discharge him from the R.A.F.

## DISCUSSION

**Symptoms.**—A study of the recorded cases shows that the condition may give rise to no symptoms at all, and may only be discovered in the dissecting room or at operation for some other disease. However, this is rare. Generally acute intestinal obstruction is the presenting clinical picture, although careful inquiry then or subsequently usually discloses either a long history of chronic constipation or the previous occurrence of a number of similar but milder attacks of acute obstruction.

**Diagnosis.**—It is unlikely that the diagnosis in an acute case could be made with certainty before operation. The nearest attempt would probably be volvulus of some kind, and indeed this would be strictly correct, except that the volvulus is of an irremediable and permanent kind.

**Radiography.**—Radiography has so far contributed little to the diagnosis of this condition. Rose (1941) has not found a single recorded instance of the discovery of this abnormality during routine investigations. A barium enema examination of his own case revealed a redundancy of the left side of the transverse colon and splenic flexure similar to that shown in the case recorded above. The added criterion of fixity to the posterior abdominal wall of some portion of the transverse colon must be established before the diagnosis can be made, and this can be achieved by the manœuvre described.

**Treatment.**—In the immediate treatment of acute cases, the majority, radical measures are out of place and their employment is perhaps

responsible for the very high mortality. There are two methods of presentation at exploratory laparotomy: (1) Obstruction due entirely to volvulus of the mobile distal ileum, cæcum, and ascending colon; (2) Obstruction of the transverse colon in its tunnel posterior to the superior mesenteric vessels.

In the first group, the volvulus must be untwisted, and a cæcostomy is desirable both as a measure of bowel drainage and rest, and also as a method of eventual cæcopexy to prevent recurrence of the condition. In the second group, cæcostomy is the only rational immediate procedure.

The remote treatment is perhaps slightly more controversial. Although cæcopexy will probably prevent further attempts at volvulus, there is no guarantee that obstruction may not subsequently occur at the root of the small-intestine mesentery. It is, therefore, probably safest to treat all cases alike. Ideally the correct treatment should be excision of the cæcum and ascending colon to the right of the superior mesenteric vessels, retraction of the left portion of the transverse colon out of the mesenteric tunnel, and anastomosis of this to the severed ileum. The dangers both of obstruction and volvulus would then be avoided. However, for various reasons, this may be impracticable, as in the present case. Some form of short-circuit should then be performed, ileo-sigmoidostomy perhaps being the safest, followed by closure of the cæcostomy and cæcopexy.

I wish to thank Air Chief Marshal Sir Harold Whittingham, Director-General of Medical Services, Royal Air Force, for permission to publish this case.

## REFERENCES

- DONALD, C. (1927), *Brit. J. Surg.*, **15**, 269.  
 DOTT, N. M. (1923), *Ibid.*, **11**, 197.  
 DOYLE, L. (1937), *Ibid.*, **24**, 821.  
 GARDNER, C. E., and HART, D. (1934), *Arch. Surg., Chicago*, **24**, 942.  
 GRANT, J. W. G. (1940), *Brit. med. J.*, **2**, 783.  
 HOLMAN, C. C. (1940), *Lancet*, **2**, 101.  
 JESSOP, W. H. G. (1940), *Ibid.*, **2**, 178.  
 KING, E. S. J. (1937), *Brit. J. Surg.*, **24**, 817.  
 ROSE, T. F. (1941), *Med. J. Aust.*, **1**, 225.  
 TRUESDALE, P. E. (1935), *J. Amer. med. Ass.*, **104**, 1697.

## THE RESULT OF OPERATIVE REPAIR OF SEVERE ACROMIO-CLAVICULAR DISLOCATION

By A. N. BIRKETT, NOTTINGHAM

THE results of operative attempts to overcome the disabilities of severe injuries are always incalculable when dealing with the skeletal and locomotive systems. This short account describes the result following operation for the repair of the

coraco-clavicular and acromio-clavicular ligaments in a soldier.

The man was 29 years of age and suffered a severe initial injury (April 26, 1943), being crushed between two lorries. Presumably the force

compressing him was oblique, so that the right scapula was pushed forwards against the clavicle, which tore adrift from the acromio-clavicular and coraco-clavicular ligaments and the outer end of the clavicle was forced under the trapezius, tearing into and burying itself in the muscle, where it remained trapped. When he attended hospital X-ray examination revealed the position shown

was passed under the coracoid process and brought out again over the clavicle, down through a second hole close to the acromio-clavicular joint, under this, and out through a third hole in the outer end of the acromion. The two ends of the fascia lata were then pulled tight and sewn together on the top aspect of the clavicle. This system of fascial grafting produced satisfactory fixation of the



FIG. 67.—Radiograph, before operation, showing the extent of the dislocation.



FIG. 68.—Radiograph immediately after repair. Some degree of subluxation is present owing to insufficient tension on the fascia lata strips.



FIG. 69.—Radiograph, fourteen weeks later, showing calcification along the fascial tracts.



FIG. 70.—Radiograph eight months after operation, showing further calcification of the bony link between clavicle and coracoid process.

in Fig. 67. The clinical appearance was that of gross swelling and bruising of the shoulder and supraclavicular region.

With most acromio-clavicular dislocations the abnormal mobility allows approximate reposition of the bony fragments by manual manipulation, but in this case the clavicle appeared to be firmly trapped under the muscle and the outer end of the clavicle could not be withdrawn. As the acromio-clavicular dislocation was obviously severe, it was decided to wait the subsidence of the swelling of the soft tissues and then to carry out open reduction and retain the clavicle in position by the use of fascia lata, after the manner of the operation described by Bunnell.

I explored the region (April 30) through an incision over the outer third of the clavicle and the anterior extremity of the acromion process of the scapula. Reduction of the deformity was difficult and the clavicle had to be literally torn out of the trapezius to disimpact it. Reduction of the joint then became easy. A ribbon of fascia lata was passed down through a hole bored in the clavicle lying above the coracoid process. This

clavicle, both with regard to its approximation to the coracoid and to the re-alignment of the acromio-clavicular joint. The remains of the coraco-clavicular ligament were brought together to reinforce the fascial strip. The wound was closed and the arm supported by a bandage to take the weight off the newly-inserted fascial graft. Check radiograph of the shoulder (Fig. 68) showed that the fascia had not been stretched tight enough to prevent some degree of subluxation.

The clinical course then became uneventful; he overcame the stiffness of the shoulder and made slow but steady progress towards excellent movement and strength of the shoulder, while the clinical appearance gave no suggestion of any tendency to subluxation. Fourteen weeks after the operation he fell on his right shoulder, hurting himself, and was rather frightened lest he should have done further damage. X-ray examination was carried out and on this occasion I was surprised to see that the attempted reinforcement of the ligament had resulted in marked calcification along the fascial tracts, and it appeared that

ossification was in progress (*Fig. 69*). Function of the shoulder, however, did not seem to be greatly impaired. Improvement was steady, and a subsequent radiograph (*Fig. 70*) taken eight months after operation showed further consolidation of the bony link between the clavicle and coracoid processes. At this stage the clinical

appearance of the shoulder remained unchanged. He had stability and reasonable strength. There was some restriction of scapula movements and, in consequence, of arm movements, though this restriction was not as marked as one would imagine, and the condition appeared definitely preferable to that of persistent acromio-clavicular dislocation.

## A FATAL CASE OF TRAUMATIC THROMBOSIS OF THE INTERNAL CAROTID ARTERY

BY CAPTAIN G. B. NORTHCROFT, R.A.M.C.

A MOBILE NEUROSURGICAL UNIT, M.E.F.

AND CAPTAIN A. D. MORGAN, R.A.M.C.

CENTRAL PATHOLOGICAL LABORATORY, M.E.F.

INJURY to the neck is an occasional cause of damage to the carotid artery, which may be severe enough to be followed by a spreading thrombosis with hemiplegia. An unusual case of traumatic dissecting aneurysm of the left internal carotid artery, followed by massive infarction of the related cerebral hemisphere, is described below. The patient came under the care of a mobile neurosurgical unit stationed at a military hospital in the Middle East, and died 48 hours later, thus affording the opportunity of investigating the mechanism of the lesion at autopsy. The interest of the case lies in the problems of differential diagnosis, and in the pathological findings.

### CASE REPORT

**HISTORY.**—On the morning of Aug. 19, 1942, the patient, a signalman aged 31, was walking along a military road, accompanied by a friend, when they were overtaken from behind by a lorry travelling in the same direction. According to the statement of his friend, a piece of loose rope hanging from the side of the lorry wound itself round the patient's neck, threw him to the ground, and then unwound itself without dragging him along. He picked himself up, and, though he felt faint and was suffering from a superficial laceration in the right parietal region, he was able to accompany his friend on foot to the Unit Medical Officer. He was then sent to the nearest reception station, where a single stitch was inserted in the scalp wound. Bruising of the left side of the neck was noted at the reception station, and in view of slight amnesia he was forwarded to a general hospital for observation.

On arrival he gave a consecutive story, but on close questioning admitted that, though he heard the lorry approaching and subsequently remembered picking himself up, he had no recollection of the details of the accident, which he had obtained from his friend. As his injuries appeared to be of a trivial nature, he was detained overnight, but not actually admitted to hospital.

On the following morning (Aug. 20) a routine examination was carried out by the ward medical officer, who noted that his general condition was good. He was alert, rational, and co-operative, and was able to repeat the story given on the previous day. A

single stitch was in situ in a small wound in the right posterior parietal region. His neck showed superficial abrasions of the throat, more marked on the left side, with a swelling in the left sternomastoid, just above the clavicle, which was thought to be a hæmatoma, causing some stiffness on movement. A superficial examination of the central nervous system showed no abnormality.

An hour later, while re-dressing the scalp wound, the sister noticed that the patient did not respond readily when she spoke to him, and twenty minutes later she was recalled because it was noted by other patients that he had flopped over in bed. The sister observed jerky movements of the right arm and leg, and reported to the ward medical officer that he had had a fit. When the medical officer saw the patient fifteen minutes later, he was completely unconscious, could not be roused, and had a complete right flaccid hemiplegia.

Shortly after, he was seen by one of us (G. B. N.). The patient was unconscious but could be roused by the spoken voice. He could open his eyes and mouth when asked, but would not put out his tongue. No attempt at speech was made. On examination his cranial nerves were normal apart from a diminished right corneal reflex and right lower facial weakness. The remainder of his central nervous system showed no abnormality except a complete right flaccid hemiplegia with extensor plantar response. Routine examination of his other systems was clear.

In view of this cerebral catastrophe he was transferred to the Neurosurgical Unit for exploration. Because this followed a head injury and there had been a lucid interval, intracranial bleeding—possibly a middle meningeal hæmorrhage on the left—was suspected.

X-ray examination revealed no fracture of skull or spine.

An exploratory temporal burr hole was made two hours later (G. B. N.). There was no evidence of extradural bleeding, the dura was not tense, and on incising it, normal cerebrospinal fluid escaped. The underlying brain appeared healthy. The left lateral ventricle was tapped and 5 c.c. of clear colourless fluid, not under pressure, were withdrawn, and the wound closed.

The same evening, seven hours later, his unconsciousness had increased to deep coma, the temperature was normal, pulse 40 and irregular, and respirations 20. He had vomited once. The right flaccid hemiplegia

remained unchanged, and he had developed catatonia in the left arm.

On the following morning (Aug. 21) his general condition was worse, his respiration became bubbly, and he died, 48 hours after his accident, and 19 hours after operation.

**POST-MORTEM APPEARANCES.**—The autopsy was performed by one of us (A. D. M.) with the following findings.

On *external examination*, the body was that of a well-nourished young man. Running round the neck was a reddish band of discoloured skin, 1 in. broad, of parchment-like consistence, resulting from constriction of the throat by the rope. The pressure-mark



FIG. 71.—Showing the changes in the first 1½ in. of the internal carotid artery as a result of traumatic thrombosis.

commenced 2½ in. below the right ear and ran horizontally round the front of the neck for two-thirds of its circumference, crossing the thyroid cartilage and ending at the anterior border of the left trapezius. Below this level the left sternomastoid muscle bulged unnaturally. In the right posterior parietal region was a healing scalp wound 1 in. long. A recent vertical surgical incision, 3 in. long and closed by sutures, was present in the left temporal region.

On dissection of the *neck*, some two-thirds of the substance of the left sternomastoid muscle was found to have been ruptured, the retracted fibres forming swellings at its upper and lower ends, leaving a thinned-out strip of muscle at the level of injury. The first 1½ in. of the left internal carotid artery were transformed into a hard bluish, spindle-shaped swelling as a result of traumatic thrombosis (Fig. 71). The left common carotid and external carotid arteries were patent. On cutting the thrombosed internal carotid artery longitudinally, the mechanism of the thrombosis was revealed. The main thrombus lay just above the origin of the internal carotid artery, extending upwards for 1½ in. The original lesion was presumably a tearing of the intima and media, with extravasation of blood into the media, raising both intima and media from the outer layers of the vessel wall. As the hæmorrhage increased in size, the lumen of the vessel became narrowed, until finally the rucked-up intima and media completely blocked the lumen in the form of an inverted valve, with the thrombosed blood below it (Fig. 72). Following total occlusion, more recent thrombosis occurred above the level of injury, spreading upwards into the petrous and cavernous portions of the vessel to continue into the left middle cerebral artery, resulting in massive infarction of the left cerebral hemisphere.

The *right* internal carotid artery showed a patch of atheroma at the site of compression, 1 in. in length, but the great vessels on this side were free of blood-clot. Both internal and external jugular veins were patent. The larynx, thyroid gland, nerves, and other structures at the level of constriction were intact.

On examination of the *head*, the wound in the right posterior parietal region was seen to be purely superficial. Apart from a burr hole in the left temporal

fossa, the skull was intact. The dura mater and venous sinuses were healthy. The spread of thrombosis was found to involve the left half of the circle of Willis and most of the left middle cerebral artery. The clot extended along the first ½ in. of the left anterior cerebral artery, and throughout the left posterior communicating branch. The greater part of the left cerebral hemisphere was softened, but not unduly swollen. An attempt at collateral circulation was observed in the leptomeninges, and superficially the degree of vascularity of the meningeal vessels on each side was the same. On section of the brain, pallor and œdema of the left cerebral hemisphere were noted.



FIG. 72.—Showing the blocking of the lumen, with the thrombosed blood below.

The *thorax* and *abdomen* showed nothing of note.

#### HISTOLOGY.—

1. *Left Internal Carotid Artery.*—The lesion proved to be in effect a dissecting aneurysm of traumatic origin. The rupture occurred in the outer third of the tunica media, extravasated blood tracking along the plane of fission for the first 1½ in. of the vessel, while the inner two-thirds of the media and the intima retracted into the centre of the vessel, being pushed from below upwards by the blood-flow to form a sort of inverted valve blocking the lumen. Thrombosis occurred below this throughout the length of the denuded area, the clot distending the remaining outer part of the media and adventitia to form a spindle-shaped aneurysm. The intima previously lining the affected segment showed well-marked atheromatous changes, obviously of long standing. The underlying media showed no signs of pre-existing disease.

2. *Right Internal Carotid Artery.*—The first inch or so of the vessel showed a moderate degree of atheromatous degeneration of the intima, the media being unaffected.

3. *Brain.*—On the *left* side the meningeal vessels were congested but not thrombosed. The grey matter of the cerebral cortex was grossly œdematous, the œdema causing great distension of the pericellular spaces, each contained nerve-cell being flattened into a crescent against the wall of the space. Most of the nerve-cells were shrunken and degenerate. The supporting neuroglia was teased out into a very open network of fine fibrils. There was a notable lack of cellular infiltration, possibly due to the absence of free blood-flow through the part. Near the surface a few small perivascular hæmorrhages were observed. Many small blood-vessels were largely dilated, with apparently necrotic walls, thus obliterating the Virchow-Robin spaces; but in most of the vessels the lumen appeared to be empty apart from an albuminous fluid, some of which had exuded into the surrounding brain tissue, causing disruption of neuroglia. A few vessels contained small thrombi. In the underlying white matter the myelin sheaths were widely separated by œdema. The internal capsule and basal ganglia showed changes similar to the above. Corresponding

portions of the *right* cerebral hemisphere exhibited oedema but not degeneration.

### COMMENT

This case is interesting on account of the bizarre nature of the accident, and instructive because of the problems arising in differential diagnosis. The presence of a head injury, with a lucid interval following a short amnesia, and subsequent development of hemiplegia, naturally suggested an intracranial hæmorrhage. In this case the diagnosis of a left-sided cerebral lesion was particularly clear, in spite of the wound on the opposite side.

It is realized, in the light of the subsequent autopsy, that too great clinical emphasis was laid on the head injury. What was believed to be a hæmatoma in the left sternomastoid was, in fact, the retracted fibres of the torn muscle, a lesion which might have directed attention to the underlying artery.

The mechanism of a dissecting aneurysm is believed to be a rupturing of the inner part of the media, followed by giving way of the intima, thus allowing blood from the vessel to spread in the substance of the media, splitting it up into two layers. It is probable that in this instance the constricting and (more particularly) the tearing

force of the rope, which caused rupture of the left sternomastoid, was sufficient to damage the media of the underlying artery. The presence of atheroma at the site of injury is probably coincidental. In the course of thirty subsequent autopsies in men of military age the great vessels were opened as a routine, and in almost every case a variable degree of atheroma was observed at the bifurcation of the common carotid arteries.

### SUMMARY

A case is described with a peculiar injury to the neck (trauma caused by a loose rope hanging from a passing vehicle) followed by coma, hemiplegia, and death in 48 hours.

Subsequent autopsy showed that the injury caused a traumatic dissecting aneurysm of the left internal carotid artery, followed by a spreading thrombosis with cerebral infarction.

We have to thank Colonel H. D. F. Brand, Officer Commanding a general hospital, for permission to publish this case. The photographs were taken by Major P. B. Ascroft, former O.C. a Mobile Neurosurgical Unit. Our thanks are also due to Brigadier Hugh Cairns for the interest he has shown in the case.

## REVIEWS AND NOTICES OF BOOKS

### Fractures of the Jaws and other Facial Bones.

By GLENN MAJOR, B.S., A.M., M.S., Ph.D., D.D.S., M.D., F.A.C.S., Pittsburgh. With chapters on Radiographic Technic by LESTER M. J. FREEDMAN, B.S., M.D., and War Aspects of Jaw Fractures by ARTHUR DICK, D.D.S., M.D. 9½ × 6½ in. Pp. 446, with 225 illustrations. 1943. London: Henry Kimpton. 37s. 6d. net.

THIS is a comprehensive book covering every aspect of jaw injuries, and it is published at an opportune time when surgeons, both in civil and military practice, require a practical knowledge of fractures of the jaws.

The emergency treatment is well set out and many practical and useful methods are considered in detail. The treatment of shock is given in an up-to-date and sound fashion. The problem of anæsthesia is discussed in detail, and the pros and cons of sodium pentothal are stressed.

The general types of fixation are all described and the importance of interdental wiring is emphasized. Perhaps the best part of the book is devoted to the post-operative care of fractures of the jaws, as the author draws on his vast clinical experience at Pittsburgh.

The chapter on radiographic technique will be found of value to the surgeon who may not be *au fait* with the different positions used to show difficult fractures.

The chapter on War Aspects of Jaw Fractures by Arthur Dick will prove of value at the present time.

The illustrations are numerous and uniformly good.

**Emergency Surgery.** By HAMILTON BAILEY, F.R.C.S. (Eng.), Surgeon, Royal Northern Hospital, London; etc. Fifth edition. 8½ × 5½ in. Pp. 969 + viii, with 1039 illustrations, a large number in colour. 1944. Bristol: John Wright & Sons Ltd. 75s. net.

ALTHOUGH the fifth edition has only 25 more pages than the fourth, there are six extra chapters and over 100 more illustrations. It has been extensively revised and made as up-to-date as any book can be by the addition of an appendix containing notes on more recent advances. Full advantage has been taken of the use of colour, not only in the natural illustrations but also in the diagrams, such as those showing the pathway of urinary extravasation. That it has been produced at all is evidence of the determination both of the author and the publishers, for not only was the whole original work destroyed but the new edition was again bombed when nearly ready for publication. Nevertheless, it bears few of the stigmata of a war production; the margins are a little smaller, but the greatest loss is the ribbon bookmark!

This work has made for itself a place in the library of every practising surgeon; the early demand for a fifth edition only serves to emphasize its utility. There is scarcely any surgical emergency upon which useful guidance is lacking, and whether one agrees with every method suggested or not one can at least be certain of finding sound practical instruction in what to do and when to do it.



**Medical Clinics on Bone Diseases.** A Text and Atlas. By I. SNAPPER, M.D., formerly Professor of Medicine, Peiping Union Medical College, Peiping, China.  $10\frac{1}{4} \times 8\frac{1}{4}$  in. Pp. 225 + ix, with 30 Plates. 1943. New York: Interscience Publishers, Inc. (London: H. K. Lewis & Co. Ltd.). 67s. 6d. net.

OUR knowledge of bone diseases and their pathology has increased enormously during the last quarter of a century. Professor Snapper, who has had vast experience at the Peiping Union Medical College in China, has written and illustrated a most useful book on bone diseases. The book is unique in many ways, for the text is illustrated by some thirty excellent plates which incorporate the X-ray picture and photomicrographs of the disease. This is the only way to teach the pathology of bone diseases. Not only are the common bone diseases described and illustrated, but uncommon conditions such as Recklinghausen's disease, multiple myeloma, Gaucher's disease, lipid granuloma, osteogenesis imperfecta, and osteomalacia, are all set out in detail and beautifully illustrated.

As a work of reference this book could not be bettered.

**Orthopaedic Surgery.** By WALTER MERCER, M.B., Ch.B., F.R.C.S. (Edin.), F.R.S. (Edin.), Assistant Surgeon, Royal Infirmary, Edinburgh; etc. With a Foreword by Sir John Fraser, Bart., K.C.V.O. Third edition.  $8\frac{7}{8} \times 5\frac{1}{2}$  in. Pp. 947 + xi, with 415 illustrations. 1943. London: Edward Arnold & Co. 45s. net.

In its third edition this well-known special surgical text-book has expanded to nearly a thousand pages. New matter has been added and every chapter has been revised and brought up to date. The work has all the virtues—and some of the weaknesses—of the Edinburgh school of surgical teaching. Nothing—or very little—has been left out. In its form it is the didactic course of lectures *par excellence*—comprehensive, clear-cut, and impersonal. As such, it will for some time to come be the leading text-book of reference in this field of surgery, not only for those reading for the higher surgical diplomas, but also for the practising orthopaedic surgeon.

## BOOK NOTICES

*[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.]*

**The 1943 Year Book of Industrial and Orthopedic Surgery.** Edited by CHARLES F. PAINTER, M.D., Orthopedic Surgeon to the Massachusetts Women's Hospital and Beth Israel Hospital, Boston.  $7 \times 4\frac{1}{2}$  in. Pp. 440, with 306 illustrations. 1943. Chicago: The Year Book Publishers Inc. \$3.00.

**An Atlas of Anatomy.** By J. C. BOILEAU GRANT, M.C., M.B., Ch.B., F.R.C.S. (Edin.), Professor of Anatomy in the University of Toronto. In two volumes.  $11 \times 8\frac{1}{2}$  in. Vol. I, Upper Limb, Abdomen, Perineum, Pelvis, and Lower Limb. Vol. II, Vertebrae and Vertebral Column, Thorax, Head, and Neck. Pp. 390 + xii, with 460 illustrations. 1943. Baltimore: The Williams & Wilkins Co. (London: Baillière, Tindall & Cox). The set, 55s. net.

**Demonstrations of Physical Signs in Clinical Surgery.** By HAMILTON BAILEY, F.R.C.S. (Eng.), Surgeon, Royal Northern Hospital, etc. Ninth edition.  $8\frac{1}{2} \times 5\frac{1}{2}$  in. Pp. 351 + viii, with 492 illustrations, a number of which are in colour. 1944. Bristol: John Wright & Sons Ltd. 25s. net.

**Structure and Function as seen in the Foot.** By FREDERIC WOOD JONES, D.Sc., F.R.S., F.R.C.S., Professor of Anatomy, University of Manchester.  $8\frac{1}{2} \times 5\frac{1}{2}$  in. Pp. 329 + iv, with 150 illustrations. 1944. London: Baillière, Tindall & Cox. 25s. net.

**The Hospital Care of the Surgical Patient.** A Surgeon's Handbook. By GEORGE CRILE, jun., M.D., Surgeon, Cleveland Clinic, and FRANKLIN L. SHIVELY, jun., M.D., Assistant Surgeon, Cleveland Clinic. With a Foreword by EVARTS A. GRAHAM.  $8\frac{1}{2} \times 5\frac{1}{2}$  in. Pp. 184 + xv, with 21 illustrations. 1943. Springfield, Ill.: Charles C. Thomas (London: Baillière, Tindall & Cox) 14s. net.

**The Diseases of the Endocrine Glands.** By HERMANN ZONDEK, M.D. (Berlin), Director of the Medical Division, Bikur Cholim Hospital, Jerusalem. Fourth (Second English) edition. Translated by CARL PRAUSNITZ GILES, M.D. (Breslau), M.R.C.S. (Eng.), L.R.C.P. (Lond.).  $9 \times 5\frac{1}{2}$  in. Pp. 496 + viii, with 180 illustrations. 1944. London: Edward Arnold & Co. 40s. net.

**Vascular Responses in the Extremities of Man in Health and Disease.** By DAVID I. ABRAMSON, M.D., F.A.C.P.  $9 \times 6$  in. Pp. 412 + x, with 59 illustrations. 1944. Chicago, Ill.: The University of Chicago Press (London: Cambridge University Press). 30s. net.

**Regional Analgesia.** By H. W. L. MOLESWORTH, F.R.C.S. Eng., Senior Surgeon, Royal Victoria Hospital, Folkestone; etc.  $8\frac{1}{2} \times 5\frac{1}{2}$  in. Pp. 90 + viii, with 42 illustrations. 1942. London: H. K. Lewis & Co., Ltd. 8s. 6d. net.

# THE BRITISH JOURNAL OF SURGERY

VOL. XXXII

OCTOBER, 1944

No. 126

## THE EARLY HISTORY OF SYPHILIS\*

By J. JOHNSTON ABRAHAM, C.B.E., D.S.O.

SENIOR SURGEON, LONDON LOCK HOSPITALS; CONSULTING SURGEON, PRINCESS BEATRICE HOSPITAL

THOMAS VICARY, in whose memory this lecture is founded, was a humble practitioner in Maidstone, Kent, in the year of our Lord, 1527. And he might have remained a humble practitioner in Maidstone had not one of those seeming chances arisen which occur in the lives of the fortunate.

It is easy to imagine what happened.

An urgent knock at his door late one night.

"Mastery Vicary! Master Vicary! Art within?"

A cautious head at the window above, looking down at a man holding a lantern.

"Yea, what would you, Master Innkeeper?"

"Master Vicary! There is a great lord at my inn who demands your service—a right choleric nobleman, by the Rood. So make you haste, good Master Vicary!"

And that was how Thomas Vicary came to treat Henry the Eighth for what the contemporary writers vaguely called his "*bad legge*", but which seems to have been either a gumma or a syphilitic periostitis of the tibia. Evidently Vicary pleased and satisfied the King, for next year he was appointed Surgeon in Ordinary, and eight years later became Sergeant-Surgeon—a post which, indeed, he held under the three succeeding sovereigns, Edward the Sixth, Mary, and Elizabeth.

He must have been a wise and politic man, for he was four times Master of the Barber-Surgeons Company; and St. Bartholomew's elected him permanent Assistant to the Hospital for the term of his life in 1552.

His rise to fortune came from his lucky success in treating the King's syphilis. It seems, therefore, appropriate that someone should talk about the historical aspects of this disease, in a lecture dedicated to his memory. So I have taken this task upon myself.

It is a pleasant task, because the story of syphilis is the most dramatic in medical history. It was *apparently* an unknown disease in Europe until it broke out in Italy, like a plague in 1495,

and then quickly spread to France, Switzerland, and Germany. It reached Bristol in 1496, and Glasgow, Edinburgh, and Aberdeen the next year. Vasco da Gama, the Portuguese navigator, you will remember, rounded the Cape of Good Hope in 1497. He carried the disease with him



FIG. 129.—Thomas Vicary.

and it appeared in India in 1498; and from thence Chinese junks brought it to Canton in 1505. So you see that in *ten* years it had circled the known world.

It was no respecter of persons. Kings, princes, popes and cardinals, merchants and monks, all suffered. The common people died in thousands, saints and sinners alike, for at first its infectivity was not recognized. And they died horribly, with violent osteocopic pains and terrible facial mutilations such as are now only a memory. It was worse than leprosy, which up to then had been the most dreaded of all diseases. It was something so new that the physicians were at a complete loss how to treat it.

\* Being the Vicary Lecture for 1943-44, delivered on April 13, 1944, at the Royal College of Surgeons of England.

## THE ANGER OF GOD

Naturally, with memories of the Black Death, men speculated fearfully as to its origin. The Church said it was a visitation from God, because of the sins of the people; and the Emperor



FIG. 130.—The Wrath of God (Sudhoff and Singer).

Maximilian was persuaded to issue his famous "Edict against Blasphemers" in August, 1495.

The Edict stated that the disease was a "flagellum Dei", a whip of the Lord, due to the anger of God against the prevailing blasphemy of the time; and it called upon all men to repent. In the Latin version the plague was called "malum francicum". This was the first definite reference to the disease.

A year or so later the Emperor's secretary, Joseph Grünpeck, wrote the first book on the subject, probably at the Emperor's command. It was a little brochure, not very practical, for he then had no experience of the disease. But it had as a frontispiece a rough woodcut, showing the Virgin crowning the Emperor, and the Child casting arrows of wrath towards the wicked suffering from the disease (Fig. 130). Later, Grünpeck contracted syphilis himself, and issued a second edition of his work, describing pathetically what he had suffered from the disease, and still more at the hands of the physicians and the quacks who tried to cure him. But by this time he no longer stressed the point that it was a punishment from God, for had not the Pope, Alexander the Sixth, and two cardinals also been infected in the meantime. So a new woodcut had to be made with a completely different motif. Here the Emperor is shown kneeling before the Virgin, whilst the Child is sending beams of comfort to praying women suffering from the disease (Fig. 131).

## ASTROLOGY

The belief now swung over to the idea that this plague was due to the influence of the stars. Faith in astrology, it must be remembered, was universal at that time. Copernicus was an unknown lad of twenty-two in a Polish monastery. The world was still considered to be the centre of the universe, and round it rotated the sun by day and the moon and stars by night. The human

body itself was divided into twelve parts, each under the influence of one of the constellations, and the sign of *Scorpion* controlled the genitalia.

Astrologers now remembered that there had been a particularly malevolent conjugation of Saturn and Jupiter in the sign of Scorpion in the House of Mars just ten years previously, and again one year before the great epidemic. This, they suddenly realized, had been an unheeded forecast that a venereal plague would fall upon the world, and those born under the sign of the Scorpion would be particularly susceptible.

The Pope's physician, Pedro Pincto, held this view, and prophesied that the influence of the stars, and the disease arising from it, would wane and disappear by 1500. It was an unfortunate prophesy; but the memory of how the Black Death had suddenly stopped a hundred and fifty years before made it seem not unreasonable at the time.

## FRACASTOR

Fracastor, who invented the name syphilis, also favoured the astrological origin. He held the view that here one was dealing with an age-old disease which recurred epidemically centuries apart, and then only in certain infrequent conjugations of the planets, so that the memory of it was lost in between; and he rationalized his belief by explaining that these conjugations drew forth vast quantities of vapours from the earth, which induced foul putrefactions, the effluvia of



FIG. 131.—The Mercy of God (Sudhoff and Singer).

which were carried widely by air. In support of the same idea, Niccolo Leoniceo independently pointed out that the year before the epidemic there had been very heavy rains in Italy; the Po, the Tiber, the Garigliano, the Rapido, and many other rivers had overflowed their banks; and the air in the following summer, 1495, was saturated with moisture in consequence.

The common soldier had other and more mundane explanations. One was the disease started through intercourse with a prostitute who was a leper, another that it was due to the Italians poisoning the wells before retreating to Salerno from Naples. It was not until the Spanish



FIG. 132.—Hieronymus Fracastorius,  
1478-1553.

historians came into the picture that the belief that Columbus brought it back from the new world got into general circulation.

#### SIEGE OF NAPLES

But no matter how writers are divided as to its origin, everyone seems to agree that its first great violence burst forth at the siege of Naples by Charles the Eighth of France in 1495.

Charles has settled his quarrel with our Henry the Seventh by the Peace of Etaples in 1492; and thus, secure from invasion from England, was able to look towards Italy, and push his very doubtful claim to the Kingdom of Naples, against the reigning Prince, Alphonso the Second, a Spaniard. When his claim was rejected, he gathered together an army of thirty-six thousand men at Lyons in 1494 and prepared to invade Italy.

Armies in those days were not like armies to-day. There was no general conscription in Europe until the time of the French Revolution, and warring kings depended largely on mercenaries for their troops. These mercenaries, landsknight or pike-men, were recruited from free companies all over Europe; and Charles's army consisted of French, Flemings, Germans, Swiss, Burgundians, Hungarians, Slavs, some English, and lastly, be it noted, a considerable

number of Spanish mercenaries, who had been fighting in Roussillon on the French side of the Pyrenees in the previous year under Ferdinand the Catholic.

They were not a disciplined army as we understand discipline to-day. They lived on the country as they moved. They had no regular transport, but were followed by hundreds of civilian drivers, ostlers, and waggoners, carting the baggage of the army in front of them. And with this cumbrous transport train travelled the sick and wounded, for there were no hospitals to evacuate back to. Also accompanying them were women and even children, the wives and offspring of these men, besides crowds of prostitutes. Charles's army had eight hundred prostitutes as camp followers.

It was an army of this sort that arrived at Naples on Feb. 22, 1495. There was no real siege of Naples. The troops of Alphonso the Second were mainly Spanish mercenaries sent to his aid by Ferdinand and Isabella. They retreated south towards Salerno, and the inhabitants of Naples met the French with open arms. But before the Spanish troops left Naples they were reputed to have brought something with them from Barcelona which the Neapolitans called "*The Spanish Disease*"; the city was now heavily infected, and the virus was spreading rapidly when the French arrived.

#### SPREAD OF SYPHILIS

It is easy to reconstruct the series of events that followed: the pleasure-loving Neapolitans heaping favours on the French, the sudden accession of thousands of men, just released from discipline in a large city after an easy victory, the loose morality of the time, and finally, the extreme contagious nature of the Spanish malady—*for this disease was syphilis*.

It spread like wildfire through the army of Charles the Eighth, which was already infected from his own Spanish mercenaries. The army was decimated. Meanwhile, fresh Spanish troops had landed in Sicily to help Alphonso Fernando, King of Naples, and in face of this new peril Charles had to retreat with his weakened forces. He fought his way back through Italy, getting home again to Lyons in November, 1495. Here he disbanded his polyglot army, and from here his men carried the disease *all over Europe*. Each country called it after the name of the country it spread from. The Germans called it *Mala de Frantzios*, the English the *French Pox*. The Poles called it *Mal des Allemands*. When it arrived at Smolensk from Vilna in 1499 the Russians called it the *Mal Polonais*. The common French name for it was "*grandgorre*", and it was called "*glengore*" in Scotland when it arrived there in 1497. It caused such fear in Edinburgh that James the Fourth decreed that everyone found suffering from it should be banished to the Island of Inch, embarking from Leith sands at a certain hour on a Friday; and

anyone found with the disease in Edinburgh at sunset on the following Monday was to be branded with a red-hot iron.

In Paris, by November, 1497, it had increased so greatly that the nurses at the Hotel Dieu also began to get infected; and the authorities therefore demanded that a large hospital should be erected outside Paris to accommodate these patients. Instead, the city fathers decided that non-Parisians should be expelled outside the gates, and citizens confined to their homes. What happened, of course, was that the expelled victims crowded into the churches and claimed sanctuary, thus vastly increasing the risk of spread, for everyone now recognized its contagious nature.

Most people knew by this time that it was generally acquired in venery, but the nature of extragenital infections was not understood for years later. Fallopius thought you could get it from infected bread, Cesalpinus from poisoned wine.

#### DID COLUMBUS BRING IT?

The belief, therefore, that it was due to the influence of the stars slumped badly, particularly when the Spanish writers began to describe their experience at Barcelona after the return of Columbus from his first and second voyages in 1493 and 1494.

Amongst these writers was Ruy Dias de Isla, at that time 30 years of age, who was practising as a physician in Barcelona when Columbus made his triumphant entry into the city to be greeted by Ferdinand and Isabella. De Isla says: "*Of the disease I have much experience, for I had the care of persons from the first expedition to America, and I treated them for the disease at Barcelona*". Amongst these patients was Martin Alonso Pinçon, the Captain of the *Pinta*, one of the three ships which went with Columbus to the New World.

The malady had existed, de Isla was told, from time immemorial in the Island of Hispaniola, and it had now been acquired by sexual intercourse between Columbus's men and the native women. It spread by contagion through the fleet; and the Spaniards, never having had experience of it before, attributed the bone pains and other symptoms to the fatigue of the voyage. They thus brought the disease to Barcelona. There it spread through the city during 1493, and again in the words of de Isla: "*As it was a malady unknown and terrible, those who were witness made great vows of fasting and alms that our Lord might guard that they fall not into this evil. And in the following year, that of our Lord 1494, the most Christian Charles of France assembled many men and passed into Italy; and, by the time that he had arrived at Naples with his army, many Spaniards serving in it were infected with the evil, and very soon the army itself became infected. And the French, as they did not know what it was, thought that exhalations from the earth caused it,*

*and they called it the Mal de Naples. And the Italians having no previous knowledge called it the Mal Frances. In Castille they called it "Bubas" but I call it the serpentine malady of the Isle of Hispaniola; and the reason I call it serpentine, 'Morbo Serpentino', is because one cannot find a more horrible comparison, for as this animal is hideous, dangerous and terrible, so the malady is hideous, dangerous and terrible."* (Fig. 133.)



FIG. 133.—Title page of Dias de Isla's work on the Mal Serpentina.

Another witness was Gonzalo Fernandez de Oviedo. He was 14 years old and a page attached to Don Juan, the son of Ferdinand and Isabella, when Columbus arrived in Barcelona. He knew Columbus and many of his men, and had first-hand knowledge of what happened in 1493 and 1494. He was present at the relief of Naples and afterwards went to the West Indies. On his return to Europe in 1525 he wrote his *Natural History of the Indies*, addressed to the Emperor Charles the Fifth.

In it he says:—

"The first time this malady was seen in Spain was after the Admiral, Don Christobel Colon, had discovered the Indies and returned. Then in the year 1495, when the grand Captain Gonzales Hernandes de Cordoba took an army to Naples to the aid of Don Fernando, by the order of Ferdinand and Isabella of immortal memory, they carried the malady with them."

You will notice that de Isla said that the Spanish troops in Charles the Eighth's army infected his men during the nine months they were moving from Lyons to Naples. And that Oviedo says that the Spanish troops sent to the aid of Alphonso the Second of Naples, also carried the disease with them from Barcelona. That would account for obvious secondary symptoms not appearing until the French troops reached Naples, and for the disease breaking out rapidly everywhere along the line of route, and spreading to Switzerland and Germany in the summer of 1495.

An odd thing that Oviedo commented on was that, though the disease caused death in Europeans it was quite mild amongst the natives, producing only a few pimples. This, which puzzled Oviedo, is what one would expect to happen: the natives were largely immune; the Spaniards were not.

The third Spanish contemporary writer to discuss the origin was Bartholome de las Casas. He went to Hispaniola in 1498. There he became a priest, devoted himself to the service of the Caribbean Indians, and wrote the famous *Historia General de las Indes*. In it he says: "I interrogated the Caribs to know if the disease did not exist with them since time immemorial, and they answered that it had existed long before the arrival of the Christians".

Gradually the Spanish belief in the New World origin of the disease began to spread. Fracastor mentions it in his poem, and also in his later work *De Contagione*. But he was not convinced of its truth, preferring the astrological explanation. Later writers were more positive. The great Fallopius said: "*Columbus discovered a continent of many isles, with treasures of gold and silver. But amongst the precious metals was hidden a thorn, and aloe in the honey. For the trireme of Columbus carried the Mal Francais to Europe*".

#### MORBUS GALLICUS

It still went under a variety of names, but on the whole that of "morbus gallicus", the French Disease, was the more common. And it was not until Fracastor published his poem, *Syphilis sive Morbus Gallicus*, in 1530 that syphilis, the name by which we know it now, had ever been heard of (Figs. 134, 135).

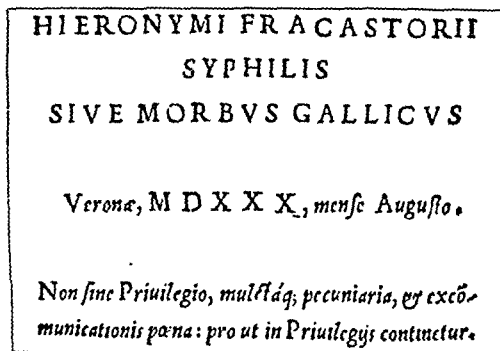


FIG. 134.—Facsimile of text of title-page of *Editio Princeps* of Syphilis, Verona, 1530.

For this name was simply an invention of Fracastor himself, intended to take the stigma from Italy as well as France. The poem is in Latin hexameters, in three books; and the story he told in Book III was that a certain shepherd in Hispaniola, Syphilus by name, drew upon himself the anger of Apollo by refusing to make sacrifices to the Sun God. As a punishment Apollo struck him with this disease; and so it was called

'syphilis' in future, because the first person to be smitten with it was the shepherd Syphilus.

Fracastor nowhere ever stated why he called the disease syphilis, but two derivations were given after his death; one *syph*, a pig, and *philos*, a lover, meaning a lover of swine; the other,

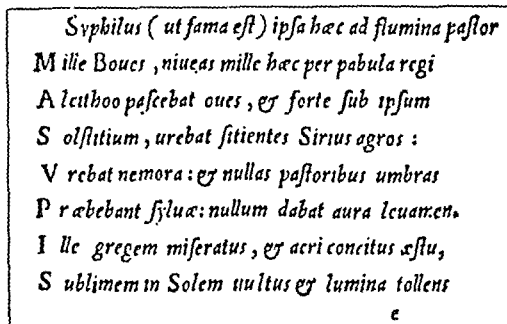


FIG. 135.—Facsimile of text of *Editio Princeps*, 1530, showing first mention of the shepherd Syphilus.

that of Fallopius: sun *philos*, companion in love. Neither is satisfactory; and the one now accepted is the explanation given in the Oxford Dictionary that Fracastor took the name from the tale in Ovid's *Metamorphoses* of Sipylus the son of Niobe, who was slain by Apollo because Niobe had insulted Latona, Apollo's mother, by boasting that she had twelve children to Latona's meagre two.

#### THE NAME SYPHILIS

Fracastor's celebrated poem is one of the most remarkable imitations of Virgil ever made by a later writer, and the name 'syphilis' therefore became widely known amongst scholars. But it did not come into general use amongst medical men in Europe before 1700, that is, for 170 years after the date of the poem. Nahum Tate, the poet laureate of William the Third, translated the poem into English verse in 1686, and so familiarized us with the name (Fig. 136); but the first time it was used in an English medical work was by Daniel Turner, surgeon to the Lock Hospital in Southwark, in 1717. Now, of course, it is used all over the world.

The early forms of treatment are very carefully described in this great poem, for Fracastor thought that the disease was dying out in his day, but that it would recur in another conjugation of the stars, centuries later, when knowledge of the treatment might be lost. And he wrote his poem in Latin, accordingly, to preserve this knowledge for all time.

#### MERCURY

Luckily at the very beginning of the epidemic mercury was stumbled upon. People washed little in those days, and the secondary lesions rather resembled those of scabies, the treatment for which was a preparation introduced, according to Guy de Chauliac, by the Arab physicians, and

called *Unguentum Saracenicum*. This, by a happy chance, contained a ninth part of mercury; and used as an inunction it cleared up symptoms rapidly. The physicians, however, obsessed by traditional theories of the four elements, the four qualities of these elements, the four humours,

time, and even later, for we find this rule still existing in Harvey's day at St. Bartholomew's Hospital.

As we know now, Dioscorides was right about mercury. It is dangerous. The curative dose and the poisonous dose are too close. The early physicians did not recognize this and patients were treated so heavily that the most horrible gangrenous signs of mercurial poisoning resulted. According to Ulrich von Hütten, the jaws, tongue, lips, and palate became ulcerated, the gums

*Et Balsamofrancos morbo gallico  
preservatio ac Cura a Bartholo-  
mico Stieber Viennensi artium  
medicæ doctore nuper edita.*



FIG. 137.—Mercury by inunction, 1498 (Sudhoff and Singer).

swelled, the teeth became loose and fell out. Saliva dribbled incessantly from the mouth and the breath became intolerably foetid—the whole apartment where a patient was treated stank unbearably, and the cure was so hard to suffer that many chose to die rather than submit to it.

It is not surprising, therefore, that physicians were appalled by the results of this treatment, and ready to grasp at any substitute that carried hope and comfort.

#### GUAIACUM

It was then that guaiacum arrived. Guaiacum came from the wood of a tree, either the *lignum vitæ* or the *lignum sanctum*, both found in the West Indies. This wood was considered sacred by the natives, who themselves used it in the treatment of syphilis. Samples reached Spain from Hispaniola in 1517, and it was said to have cured two thousand people there in the next three years. It received its greatest advertisement, however, in 1519 when the poet Ulrich von Hütten published his famous work, *De Morbi Gallici Curatione per Administrationem Ligni Guaiaci*, describing the tortures he had suffered under mercury, and the blessed relief he obtained when cured by guaiacum; and Fracastor seems to have used it from 1525 onwards. Originally only decoctions of the bark or wood were used; the gum came into use much later.

# SYPHILIS: OR, A POETICAL HISTORY OF THE French Disease.

Written  
In Latin by FRACASTORUS.

And now Attempted in English by N. TATE.

LONDON,  
Printed for Jacob Tonson, at the Judge's-Head in  
Chancery-lane near Fleetstreet. 1686.

FIG. 136.—Facsimile of title-page of First English Translation by Nahum Tate.

and the six non-naturals of Galen, proceeded slowly. They prescribed appropriate diets, exercises, purgatives, and then used mercury in a strength of one in forty. The quacks, however, rushing in blindly, used the ointment at once up to a strength of one in eight and got quicker and more dramatic results. This forced the hands of the physicians, with disastrous consequences.

The drug was given in three ways: by inunction or plasters applied to various parts of the body (Fig. 137), by inhalation, and by fumigation. Fracastor mentions in his later work that it was also given in pill form, but condemns this as very dangerous because both Dioscorides and Galen said it rotted the guts. Actually Francis the First, a contemporary of our Henry the Eighth, was treated with some success by pills sent as a courtesy to him by Barbarossa, the Algerian corsair; and physicians were eventually forced to use the method also. But surgeons were interdicted by law from giving internal treatment at that

At first the drug was received with a burst of enthusiasm. Fracastor in his poem describes how the shepherd Syphilus was cured by it, after Apollo had relented. But enthusiasm began to die down as failure after failure came, and it was found not to be as effective in controlling symptoms as the dreaded mercury. It was then that another drug came into fashion, 'China Root', *Smilax sinensis*, in 1535, and for a while largely supplanted guaiacum. It, too, however, presently fell into disfavour and, largely owing to Fallopius, guaiacum came back, especially after it was said to have cured the Emperor Charles the Fifth of rheumatism. This reputation and the dread of mercury kept guaiacum in the pharmacopœia of every nation in Europe for the next four hundred years; and it was still official in the B.P. of 1914, combined with calomel in Plummer's pill; and it is used with sulphur in "Chelsea Pensioner" even unto this day. But, of course, the glory has now departed.

#### SARSAPARILLA

Another drug which was introduced a little later than Fracastor's time was sarsaparilla, prepared from the root of a South American plant *Smilax ornata*. It, too, has had a long run in popular favour as a 'blood purifier'. It is still sold at fairs by itinerant quacks. It was official in the British Pharmacopœia as Decoct. Sarsæ Co. Con. up to 1914. *Sassafras officinale* was another American plant used. It also survives with sarsaparilla in Decoct. Sarsæ Co.

Such were the drugs which were employed in the treatment of this fell malady for three hundred and sixty years, before anything else was added to our armamentarium.

#### CONFUSION BETWEEN SYPHILIS AND GONORRHOEA

And now we come to a very odd episode in the history of the disease. In Fracastor's time syphilis and gonorrhœa were so vividly distinct in men's minds that confusion between them was impossible. But even before his death the curious heresy began to develop that the two diseases were the same. John of Bethencourt is said to have started it in 1527. Paracelsus called syphilis 'French Gonorrhœa' in 1536, and he was largely responsible for spreading the heresy. Ambroise Paré supported him; and it is easy to see how, before modern microscopy, a man getting gonorrhœa after one intercourse, and some weeks later developing a chancre without taking any further risks, might readily think it was all part and parcel of the same disease. It is difficult for us now to realize that this heresy divided the medical world for three hundred years into two very violently opposed camps: the monists who said that syphilis and gonorrhœa were one and the same disease, and the dualists who stuck out for their being two distinct conditions. The great Sydenham believed in the monist view, and so did most of the Continental writers.

Paracelsus divided the disease into two types: simple gonorrhœa which developed no constitutional symptoms, and virulent gonorrhœa which caused the symptom of syphilis.

In simple gonorrhœa there was an ulcer inside the urethra which caused a discharge of pus; in virulent gonorrhœa, or syphilis, the ulcer was outside as a chancre.

Paracelsus, of course, was a great genius, a violent opponent of everything Galenical, and a fierce advocate of the metals and inorganic compounds which were to play so important a part in the medication of the next two centuries. He had no use for decoctions of herbs; so he tried one metal after another until he finally pinned his faith on mercury.

Thereafter he thundered in and out of season in its favour, aided and abetted by Ambroise Paré, another genius looked askance upon in his time by the timid regular practitioner. Between them they established it as the specific, a position which it maintained without any serious rival for four hundred and twenty years.

And so, after the preliminary overdosage which had been so fatal, practitioners settled down to the belief that treatment to the point of marked salivation was sufficient. The disease it was believed, was produced by a thick phlegm, pituita, one of the four humours. Mercury made this phlegm more liquid, and the evil humour was thus expelled in the saliva.

Naturally, the more saliva produced the more evil humour was expelled; and pewter spitting pots were, therefore, placed at the patients' bedsides to measure the saliva. Pots marked up to two or even three pints were used, and the surgeon doing his rounds looked at them daily. If there was not as much saliva as he thought necessary, the dose of mercury was increased. But human nature being what it is, patients, it is said, soon learnt to add water surreptitiously to the pots to avoid increase in dosage.

You will remember that there had always been two opposing beliefs as to the American or non-American origin of the disease. Naturally, then, when the views of Paracelsus on the identity of the two diseases, syphilis and gonorrhœa, gained credence, this greatly strengthened the argument that syphilis in Europe was pre-Columbian; for, of course, everyone knew that gonorrhœa had existed in Europe long before Columbus's time. And so the Bible and the Greek and Latin classics were searched for evidence, and Job, King David, Solomon, Socrates, and Nero were all said to have had syphilis, and every vague reference to mutilating diseases, especially of the genitalia, was quoted as proof positive of its old-world origin.

When one remembers, however, that cancer, lupus, ulcus molle, phagedena, scabies, leishmaniasis, granuloma venereum, and lymphogranuloma inguinale all existed in the old world before the time of Columbus, the evidence from these vague references is not very convincing.



## JEAN ASTRUC

In spite of all this confusion of thought, however, clinical knowledge grew. The fact that the disease could be carried by kissing and domestic utensils was recognized. Digital chancre



FIG 138—Jean Astruc. (From Pusey's "*History of Syphilis*".)

in doctors and midwives had been noted. Hereditary transmission was known, and syphilitic aneurysm described. Indeed, apart from the specific origin of tabes and G.P.I., practically all the clinical signs were clearly differentiated before 1736, the year in which Jean Astruc, physician to the King of Poland, published what is still the most scholarly work ever produced on the subject.

Astruc was a very learned man, a profound classical and Hebrew scholar, and a violent pamphleteer against the great regiment of quacks, amongst whom venereal disease has always been a happy hunting ground. Astruc was a strong supporter of the American origin of syphilis, in spite of his belief in the unity of syphilis and gonorrhœa. His reputation indeed was so great that he may have subconsciously influenced John Hunter to draw the disastrous conclusions he made from his own experiments between 1753 and 1767.

## HUNTER'S FATAL EXPERIMENT

Hunter tried to take nothing for granted. You will remember that the orthodox view was that gonorrhœa was caused by an ulcer inside the urethra, and syphilis by an ulcer outside. To test this, Hunter, in the spring of 1753, did post-mortems on eight men who had been hanged at Tyburn. Two of these were known to have had severe gonorrhœa, but on examination he found no ulceration in the two urethras. Instead they appeared merely a little bloodshot, especially near the glans. That disposed of one fallacy.

But he was not so fortunate with the other. To test the theory of the supposed identity of syphilis and gonorrhœa he made, in the year 1767, two punctures with a lancet, one on his foreskin, one on his glans. Into these punctures he rubbed "the matter of a gonorrhœa". Unhappily the case was one of mixed infection, and Hunter developed a chancre and the syphilis from which it is possible he died.

It was a most unfortunate accident both for Hunter and for science, because, on the strength of his great name, the waverers were satisfied and the whole of Europe practically accepted the monist view.

## BENJAMIN BELL

Almost everyone followed Hunter. Almost, but not quite. There had always been doubters in England. We had memories of the older disease before the arrival of the French pox. So there were still doubters, and characteristically one was a brother Scot. Benjamin Bell, of Edinburgh, published his work on venereal diseases in 1793, and in this he stated that he had introduced a stylet charged with the virus of syphilis into the urethra of one of his students. Eight days later there was no sign of gonorrhœa, but soon afterwards the student developed syphilis, and had to be cured by inunction.

Two more of his students then introduced small pieces of lint charged with "the matter of a gonorrhœa" underneath their foreskins. One got a violent gonorrhœa which took a year to



FIG. 139.—Benjamin Bell (Pusey)

clear up. The other got a severe balanoposthitis. Neither got syphilis.

Finally, one of these boys, nothing daunted, introduced the secretion of a chancre inside his urethra. Ten days later there were no signs of gonorrhœa, but twenty-six days later he developed a chancre in his urethra at the point of contact. This, Bell considered clear proof that the diseases were quite distinct.

But unfortunately the world took no notice of Benjamin Bell; and surgeons everywhere

treated gonorrhœa with mercury to salivation, in spite of Hunter's own warning that this was useless. And the heresy thus unhappily strengthened lasted for nearly seventy years.

#### FAILURE OF MERCURY IN GONORRHŒA

Gradually, however, the non-success of the mercurial treatment in gonorrhœa caused doubts. Abernethy, in his work, *Observations on Diseases Resembling Syphilis*, dared to say that "Diseases that spontaneously got well were not syphilitic", and Astley Cooper refused to treat his cases of gonorrhœa with mercury.

#### RICORD

Men's minds were therefore ripe for Philippe Ricord's masterly work which appeared in 1838 and proved conclusively by over one thousand and forty experiments, carried out mainly on lunatics, that the two diseases were absolutely different.



FIG. 140.—Philippe Ricord (*Pusey*).

#### OVERDOSAGE

Overdosage of mercury by this time had again produced a violent reaction against its use. Many physicians indeed, seeing the horrible effects of this overdosage, now held the view that tertiary symptoms were produced by mercury, not by syphilis; and, encouraged by John Thompson, Professor of Surgery at the College of Surgeons, Edinburgh, refused to use it, falling back on antiphlogistics, rest in bed, and sudorifics, including guaiacum and sarsaparilla. Sir William MacGregor went so far as to make this treatment official in the Army, and the demise of mercury as a specific was once again pronounced.

This helped the unfortunates with gonorrhœa, who were thus saved what was for them a nauseating, dangerous, and useless treatment, but it did not help the syphilitics.

Trouble started again.

You can therefore understand the excitement that spread throughout the profession when there appeared in *The Lancet* for 1835-36 a series of articles on a new drug which promised to do all

that mercury did without the risk attached. Cases that had proved intractable to mercury were cured like magic. Old tertiary cases that nothing would touch cleared up. Gummata melted away. The new drug was hailed as a cure-all and everyone hastened to use it.

#### IODIDE OF POTASH

The drug was introduced by William Wallace, of Dublin. It was iodide of potash, and it is difficult now to visualize what a stir it made when it was introduced.

Only those who remember the claims made for '606' when it was introduced in 1910, and one injection was supposed to cure the disease, can have any idea of the excitement produced. Wallace was an extraordinary man, and but for his untimely death would have become world-famous.

The extreme contagious nature of syphilis was a commonplace in Fracastor's time. The fifteenth and sixteenth centuries accepted this contagiousness at all stages of the disease. But the confusion introduced by gonorrhœa obscured the infectivity, and Hunter thought that only the chancre was contagious.

Ricord, who had proved that syphilis and gonorrhœa were distinct diseases, was the first to differentiate syphilis into primary, secondary, and tertiary. Nevertheless, he made the same mistake as Hunter, teaching that the *secondary lesions* were not contagious. He believed this because he found he could not start fresh lesions in his syphilitic patients by scratching their skins, and trying to inoculate the virus from mucous patches or condylomata. He was ignorant of the fact that it is almost impossible to do so in a syphilitic twelve days after the primary sore appears—because the skin of a syphilitic is by that time practically immune to any such attempt.

#### WILLIAM WALLACE

Wallace, of Dublin, who knew of Ricord's views, tested them out by inoculating *healthy* out-patients from the secondary eruptions of his syphilitic patients, and soon proved that Ricord was wrong. He published his results in *The Lancet* early in 1837, and no one seems to have been in the least horrified at his method of proof.

Wallace had a very original mind. He was extremely interested in dermatology and started the first skin hospital in the British Isles in 1818. He was an Ulster man, born at Downpatrick in 1791, and was appointed surgeon to Jervis Street Hospital in 1815. He was a contemporary of Colles in Dublin, and a bitter rival. When Colles's historic work on syphilis appeared, in which the famous 'law' that a syphilitic child could not infect its mother was stated, Wakley of *The Lancet* sent the book to Wallace to review. This review was a savage onslaught, for Wallace believed that Colles had jumped his claim, and that he was the original discoverer of the 'law'.

He died very tragically of typhus in the winter of the same year (1837), so the controversy died with him. But probably he was unjust to Colles, for when one is teaching students, or talking to professional brethren, especially in a small city like Dublin, one's views get disseminated, the thing is in the air, and the first to print an observation gets the credit for it.



FIG. 141.—Abraham Colles (*Pusey*).

Ricord, great man though he was, never quite admitted that he had been wrong about the non-infectivity of secondary lesions. He refused to accept Wallace's results, when they were brought to his notice. But the controversy over these auto-inoculations started another very curious episode in the history of the disease.

Soft sore by now had become more or less recognized as somewhat different from hard chancre. Ricord himself had noticed that it was very readily inoculable all over the body, that it caused no constitutional symptoms, and that it could be cured by topical applications. But he still thought it was syphilitic.

In spite of this, Bassereau the elder stated in 1852 that, in his opinion, *ulcus molle* and syphilis were two distinct diseases. But the great Ricord would have none of this. He maintained the unity of the two diseases obstinately up to the time of his death; and his prestige was so great that his opinion swayed the French medical world, and even affected the English.

The importance of this historically is that a very curious line of treatment developed from it called *syphilization*.

Jenner, it was pointed out, prevented small-pox by vaccinating with cow-pox. Therefore, why not try to prevent, modify, or cure syphilis by inoculation with the pus of soft sore, which according to Ricord, was an attenuated variety of syphilis!

### SYPHILIZATION

This line of treatment was started by Monsieur Auzias-Turenne about 1850. His method was to inoculate his patients with pus from a soft sore, starting on the trunk and re-inoculating from each fresh sore again and again, ending up on the thighs and arms.

In this way the sores grew smaller and smaller, until eventually they ceased to take. The victim was then thought to be immunized, or, if he were a syphilitic already, he was supposed to be cured. The process took on an average six months.

Auzias-Turenne suggested that prostitutes should be protected in this way, and anyone else liable to contract syphilis. If one had already, unfortunately, got the disease it was supposed to shorten treatment, and to prevent late recurrences. He was such an enthusiast that he ignored the fact that there was an element of danger in this, as there was always the chance that a healthy person might get active syphilis by mistake. It was the same risk, of course, that people took who were purposely inoculated with the active virus of small-pox in the eighteenth century, before Jenner introduced vaccination in its place. But if the theory was correct it seemed quite a reasonable procedure.

The Auzias-Turenne treatment was tried at the London Lock Hospital by Coulson in 1865, but it was quickly abandoned as useless. He found it practically impossible to re-inoculate syphilitics from mucous patches, and that inoculations from soft sore had no appreciable effect on the disease. Other observers found also that, after as many as three hundred inoculations, there was no immunity; and gradually the treatment fell into disuse.

Auzias-Turenne, however, vehemently maintained and supported his views before the Medical Societies of Paris until the time of his death about 1878. He was fanatical on the subject. After his death it was found that his whole body was covered with the scars of experimental inoculations he had done on himself—a pathetic proof of his faith in his own treatment.

So ended a curious and almost forgotten page in the history of this protean disease.

### LAZAR HOUSES

And now I should like to go back a little historically. You will remember that, when syphilis burst upon Europe, panic methods of segregating the victims, such as those tried in Paris and Edinburgh, proved how unprepared the world was to cope with the disease.

England, however, was more fortunate than most countries, for England had a large number of lazaret houses built by the pious for the treatment of lepers—the one type of patient medieval hospitals would not admit.

Hospitals, as you know, were then really religious houses where the monks looked after the sick. These hospitals were attached to the monasteries; and in them the sick, the halt, and

the blind were admitted and cared for without distinction—all except the lepers, for medieval Europe had a profound horror of lepers. Instead, for them, wandering along the highways with their begging bowls and rattles, special lazaret houses were erected close to the monastery gates; and there at sundown the real lepers, as well as the men covered with the foul ulcers of untreated scabies, the victims of lupus and rodent ulcer—all loosely diagnosed as lepers—were segregated.

Outside each lazaret house were two large wicker baskets filled with rags, tow, wool, hay, etc., and with the contents of these baskets the patients wiped their sores before admission. The baskets were called *Les Loques* (French for rags), the patients were also called *Les Loques*, the ragged ones, and the lazaret houses in Norman England, by transference of idea, came to be known as *Les Lock* in consequence.

### LOCK HOSPITALS

Towards the middle of the fifteenth century, leprosy was rapidly declining in Europe. This was particularly so in England, and when syphilis started, naturally the almost empty lazaret houses were turned over to the use of venereal disease. It was in this way that the name '*Lock*' became associated with syphilis.

When, however, the monasteries were suppressed in the reign of Henry the Eighth, the lazaret houses went with them, and most of these were converted into barns or business premises.

St. Bartholomew's Hospital, however, was allowed by its charter to keep seven of these lazarets, locks, or outhouses as they were called. They ranged from Mile End in the East to Hammersmith in the West, from Southwark in the South to Finchley in the North. And Thomas Vicary, as the resident surgeon in 1552 at the hospital had to visit and treat the patients. That they were badly needed is evident from William Clowes's statement twenty-five years later that of every twenty patients at St. Bartholomew's fifteen were syphilitic. But in spite of this need, because of the cost of upkeep, the number of lazarets in use gradually fell, until in 1621 only two were left: The Lock for men in Kent Street, Southwark, and the '*Spital*' for women in Kingsland. Each had thirty beds and the surgeons were paid £4 a year as salary. By 1682, however, the salary had been raised to £30 a year, a house, and £50 per annum for medicines.

The posts at these Locks were always held by the two senior assistant surgeons to St. Bartholomew's; and Percivall Pott is said to have broken his leg returning to St. Bartholomew's from the Lock Hospital in Southwark.

The two Locks were costing Bart.'s £700 a year in 1754, just at the time when the three great new blocks were being built at Smithfield, and the hospital was very hard pressed for money.

A motion to close down the Locks was accordingly put before the Court of Governors. It was defeated.

But it was again brought forward in 1760; and this time it succeeded. The two Locks controlled by St. Bartholomew's for several hundred years ceased to exist as such, and wards were allocated to the treatment of venereal disease in the hospital itself, thus following the custom of St. Thomas's Hospital, which had always had venereal wards.

### WILLIAM BROMFIELD

Fourteen years previously, however, William Bromfield, a surgeon at St. George's Hospital, became greatly exercised over the rapid increase in venereal disease in the West End of London. He decided something must be done, and after consulting the Princess Royal, to whom he was surgeon, he got around him a number of distinguished and philanthropic gentlemen, and started the present London Lock Hospital on July 4, 1746.



FIG. 142.—William Bromfield, founder of the London Lock Hospital. (From the original portrait in the Hospital Board Room.)

They bought a house below St. George's Hospital on a ninety-nine year lease for £350 from Sir Robert Grosvenor, and started their hospital with a subscription list amounting to £138 1s. 6d. That it was badly wanted is shown by a comment in the report for 1758 which says that of the four hundred and forty-two patients admitted in that year over "*one hundred were married women, some with infants sucking at the breast, many of whom were admitted by the weekly committee without any recommendation, almost naked, penniless, and starving*".

When the hospital was founded in 1746 near Hyde Park Corner, it was on open ground infested by footpads on the outskirts of London; but by 1842, when the lease was due to expire, it was surrounded by the mansions of Belgravia, and the Grosvenor Estate, therefore, refused to renew its tenure.

The Governors accordingly decided to buy a freehold. That was why they moved to Harrow Road, where they bought from the executors of Mrs. Siddons, the actress, her cottage and four acres of ground on Westbourne Green. Here they built the present hospital, and a few years later opened their out-patients' department in Dean Street. Incidentally it should be noted in passing that Dublin founded its Lock Hospital in 1755, Glasgow followed suit in 1805, and both these institutions are still working.

We now approach times that are more familiar to us. Jonathan Hutchinson, in 1863, drew attention to his triad in congenital syphilis: eighth-nerve deafness, Hutchinson's teeth, and interstitial keratitis.

Fournier in Paris had by then assumed the mantle of the great Ricord, and it was he who popularized the belief that the disease could be cured without severe salivation. He stressed the

understand Osler's remark that if you knew your syphilis you knew your medicine, for physicians up to the year 1900 had to be very 'syphilis-conscious' because they had nothing but their clinical sense to guide them—the spirochæte was still undiscovered and the Wassermann unknown.

That was the end of an epoch, and it brings us logically to the end of the early history of syphilis. But it is sobering to think that in spite of all the vaunted progress of the nineteenth century, if Vicary had visited any venereal hospital in 1900, he would have been familiar with practically every treatment given.

For all the great advances have been crowded into the years from 1905 until to-day.

And the end is not yet.

For, if there is anything in recent experimental work, we may be on the verge of treatments even more revolutionary than those of the last forty years; and it is possible that this curse on humanity may eventually become merely a memory of:—

"Old unhappy far-off things  
And battles long ago".

#### BIBLIOGRAPHY

The bibliography of syphilis is so overwhelming that nothing more than a general indication of main sources can be given.

- ACTON, WM., *On Prostitution*, 1870, 2nd ed. London.  
 ASTRUC, JOHN, *A Treatise on the Venereal Disease*. Wm. Borrowby's Translation from the Latin, 2nd ed., 1754. London.  
 AUZIAS-TURENNE, JOSEPH ALEXANDRE, *Origines de la Syphilisation. Lettres à l'Académie des Sciences de Paris* (1844-50), 1878. Paris.  
 — — *La Syphilisation*, 1878. Paris.  
 BELL, BENJAMIN, *A Treatise on Gonorrhœa Virulenta and Lues Venerea*, 1793. Edinburgh.  
 CAMERON, CHARLES, *History of the Royal College of Surgeons, Ireland*, 1916, 2nd ed. Dublin.  
 CLOWES, WM., *A Short and Profitable Treatise touching the Cure of the Morbus Gallicus by Inunctions*, 1579. London.  
 COLLES, ABRAHAM, *Practical Observations on the Venereal Disease*, 1837. London.  
 COULSON, W. J., *A Treatise on Syphilis*, 1869. London.  
 FOURNIER, ALFRED, *Syphilis et Marriage*, 1880. Paris.  
 FRACASTORO, GIROLAMO, *Syphilis, or the French Disease*. Trans. by H. Wynne-Finch, 1935. London.  
 — — *De Contagione*. Trans. by Wilmer Cave Wright, 1930. New York.  
 GALE, THOMAS, *Certaines Works of Chirurgie*, 1563. London. (The first mention of syphilis in English.)  
 HUNTER, JOHN, *A Treatise on the Venereal Disease*, 1786. London.  
 HUTCHINSON, JONATHAN, "On Heredito-syphilitic Struma", *Brit. med. J.*, 1861, I, 515-17.  
 — — *Syphilis*, 1887. London.  
 HÜTTON, ULRICHUS DE, *De Morbo Gallico. A Treatise of the French Disease, published about 200 years past, by Sir Ulrich Hutton, Kt., of Almayn in Germany*, ed. by Daniel Turner, 1730. London.



FIG. 143.—Alfred Fournier (Pusey).

point that treatment should be slow, intermittent, and spread over at least two years; and taught that marriage was not safe for five years after infection. Hutchinson strongly urged the same views in England, and it is to the influence of these two great men that the short intensive treatment previously in vogue came finally to be condemned.

But, of course, the two-year treatment was slow; secondary signs disappeared tardily, and tertiary sequelæ, or what Hutchinson called "reminders" were very frequent. For this reason the proportion of hospital patients suffering from syphilis was much higher in Victorian times than it is to-day.

At St. Bartholomew's, for instance, in 1879, according to Acton, 48 per cent of Paget's out-patients were venereal. We can therefore

- (A translation of Ulrich von Hütton on treatment by guaiacum.)  
*Index Catalogue of the Library of the Surgeon-General, United States Army.* [In this will be found practically any reference of value, especially after 1900. It is constantly kept up to date.]
- LANE, J. R., and GASKOIN, G., Record of Cases treated in the Lock Hospital by Syphilisation, *Med. Chir. Trans.*, 1867, L.p. 281. London.
- LONDON LOCK HOSPITAL, General Court Book, 1746-1762.
- LUISINUS, ALOYSIUS, *Aphrodisiacus* (Langerak and Verbeek), 1728. Leyden. [This is a collection of all the earlier treatises on syphilis—a very important source book.]
- MATHIAS, ANDREW, *The Mercurial Disease . . . produced by the use of Mercury, with Observations on its connection with the Lues Venerea*, 1810. London.
- MAYNWARINGE, EVERARD, *The History and Mystery of the Venereal Lues*, 1673. London.
- MOORE, NORMAN, *History of St. Bartholomew's Hospital*, 1918. London.
- POWER, D'ARCY, "Thomas Vicary", *Brit. J. Surg.*, 1918, 5, 459-362; 1920, 8, 240-258.
- PROKSCH, I. K., *Die Litteratur der Venerischen Krankheiten*, Bonn, 1889-91, with supplement bringing the work up to 1900. [This vast compilation is the most important of all the bibliographies. It is essential to any serious student of the history and epidemiology of the disease.]
- REES, GEORGE, A chronological account of the English writers on the subject from 1735, when Dr. Astruc concluded his historical account, to 1785, 1802. London.
- RICORD, PHILLIPE, *Traité pratique des Maladies vénériennes*, 1838. Paris.
- *Lettres sur la Syphilis*, 1863. Paris.
- St. Bartholomew's Hospital Reports, 1886. An Historical Account of the Lazar Houses attached to the Hospital.
- SUDHOFF, KARL, and SINGER, CHARLES, The earliest printed Literature of Syphilis (facsimile reproductions), Florence, 1925. [This is also well illustrated mainly from Sudhoff's *Graphische Erstlinge der Syphilisliteratur*, 1495-1496. 1912. Munich.]
- WALLACE, WM., *A Treatise on the Venereal Disease*, 1833. London.
- *Lancet*, 1835-36, 2, 5.
- Origin of Syphilis.**—Opinion for and against the American origin of syphilis is so divided, the following should be consulted for the evidence:—
- BASSEREAU, EDMOND, P. M., *Origine de la Syphilis*, 1873. Paris.
- BLOCH, IWAN, *Der Uersprung der Syphilis*, 1901-11. Jena.
- HALTOM, W. L., and SHANDS, A. R., jun., "Evidence of Syphilis in Mound Builders' Bones", *Arch. Path.*, Chicago, 1938, 25, 228-242.
- HOLCOMB, R. C., "Ruy Dias de Isla and the Myth of Haitian Origin of Syphilis", *Med. Life*, 1936, July and November.
- JEANSELME, EDWARD, *Histoire de la Syphilis*, 1931. Paris.
- OHMANN-DUMESNIL, A. H. (Buret), *Syphilis in Ancient and Prehistoric Times*, 1891. Philadelphia.
- PUSEY, WILLIAM, *The History and Epidemiology of Syphilis*, 1933. Springfield.
- ROBINSON, V., "Birth of Syphilis", *Arch. Derm. Syph.*, Chicago, 1937, 36, 325-330.
- SUDHOFF, KARL, *Aus der Fruhgeschichte der Syphilis*, 1912. Leipzig.
- THORNDIKE, L., "Possible References to Syphilis before Discovery of America", *Bull. hist. Med.*, 1942, 11, 474.
- VORBERG, G., *Ueber den Uersprung der Syphilis*, 1924. Stuttgart.
- WHITWELL, J. R., *Syphilis in Earlier Days*, 1940. London.

## SOME EXPERIENCE OF REPARATIVE SURGERY IN THE MIDDLE EAST

### WITH A SHORT REVIEW OF 1200 CASES TREATED DURING THE LAST TWO YEARS

BY MAJOR MICHAEL C. OLDFIELD, M.B.E.

HON. ASSISTANT SURGEON, THE GENERAL INFIRMARY AT LEEDS

A BRIEF review has been made of the first 1200 cases treated by a Maxillo-facial Unit in the Middle East. Most of the patients were wounded during the Syrian, Libyan, and Tunisian campaigns, and had received preliminary first-aid or primary treatment before arriving at this unit. However, in the early part of the campaign which started at El Alamein, a number of battle casualties arrived within 24-48 hours of receiving their wounds. Many of the recent patients have been evacuated by air and their condition on arrival and subsequent progress has been notably better than in the case of similar casualties from the early Libyan and Syrian battles where evacuation took 5-10 days and was made by motor ambulance and train.

#### CAUSES OF INJURY AND DEFORMITY

	Cases
Gunshot wounds	456
Burns	190
Accidents	452
Disease, new growths, etc.	102
Total	1200

Even though the Middle East has been the most active theatre of war for British troops during the last two years, the proportion of accident cases to battle casualties has been remarkably high.

**Anæsthetics.**—Intratracheal anæsthesia, introduced by Dr. Magill and so ably practised by Capt. A. W. Raffan and Capt. F. G. Mackintosh

for my unit, has made facial and jaw operations much safer for the patient and the work of the plastic surgeon has been simplified. In the majority of cases a preliminary induction has been performed by the intravenous injection of sodium pentothal (usually about 0.25 g.). Not only is this method of induction a great boon to the patient, but some such quiet induction is absolutely essential for a patient who requires repeated anaesthetics for a 'multiple stage' plastic repair. When for some special reason, such as a chest complication, local anaesthesia was used, it was always preceded by heavy premedication—for instance, morphia (gr.  $\frac{1}{2}$ ) and hyoscine (16 gr.) one hour before the operation and intravenous morphia (gr.  $\frac{1}{2}$  or  $\frac{1}{4}$ ) given in the theatre before the operation started. Continuous intravenous pentothal is rarely suitable for plastic surgery of the face.

**Dressing of Wounds.**—If plastic surgery is to be undertaken amongst battle casualties, it must be associated with a rigid technique of wound dressing. The technique of dressing is nearly as important as that of the operation; unless stringent precautions are taken hæmolytic streptococci and *B. pyocyaneus* will work havoc in a 'plastic ward'. It is significant that these organisms are rarely present in the wound before a patient is admitted to a hospital. If, however, the wounds of battle casualties are swabbed after being dressed for some time in a general hospital the majority are found to be infected by hæmolytic streptococci and *B. pyocyaneus*. If the ritual, so lucidly expounded by Colebrook and his colleagues, is carried out, the fear of streptococcal infections will cease to exist. Whereas the majority of streptococcal infections can be controlled by soap baths and the use of the sulphonamide drugs or penicillin, infections by *B. pyocyaneus* appear at present to be almost unassailable.

**Classification of Plastic Operations.**—In order to give an outline of the methods of plastic repair which we have used in the treatment of the common types of deformity which occurred during the recent Middle East campaigns, we decided to classify them under the following headings:—

#### 1. Face.—

- a. Nose.
- b. Orbit.
- c. Cheek.
- d. Lips, mouth, and chin.
- e. Ear.
- f. Fractures of the mandible and maxilla.
- g. Fractures of the malar bone.

#### 2. Neck, trunk and genitalia.

#### 3. Hand and upper extremity.

#### 4. Lower extremity.

#### 5. Burns.

#### 6. Repair of fistulous openings.

Most of the procedures adopted have been based upon classical and well-established methods described and perfected by such doyens of plastic

surgery as Gillies, Kilner, Mowlem, De Vilray, Blair, and Brown. Although small modifications of technique have been added from time to time so few of the essential procedures have been in any way original that detailed description of operative technique has been omitted.

## METHODS OF TREATMENT

TABLE SHOWING THE ROUTINE METHODS OF PLASTIC REPAIR IN THE 1200 CASES UNDER REVIEW

1. Free grafts —		
a. Skin —		
Razor	252	
Wolfe	51	
Dermatome	9	
Pinch	83	
	—	395
b. Bone :		
Mandible	8	
Malar	9	
Supra-orbital margin	2	
Nasal bridge	19	
	—	38
c. Fascia		1
		— 434
2. Tubed Pedicles		25
3. Open Flaps —		
a. Direct		34
b. Transferred via hand or wrist		4
		— 38
4. Local Plastic Operations to Face (e.g., Rotation flap, scar excision, etc.)		270
5. Nose Reconstruction by Forehead Flap		14
6. Nose Repair (e.g., manipulation of nasal fractures—nasal re-fractures and re-arrangement of displaced tissues of nose)		108
7. Malar Replacement		43
8. External Pin Fixation —		
a. Mandible	18	
b. Malar	12	
	—	30
9. Various Jaw Operations (e.g., sequestrectomy, manipulation of fractures, treatment of dental cysts, etc.)		235
10. Repair of Fistulae		37
11. Upper Extremity—skin-grafts and other plastic operations		101
Including :		
a. Webbing of axilla, repaired by dermatome or thick razor grafts associated with a modified 'Z' plastic	6	
b. Direct flaps	10	
c. Abdominal tubed pedicle to hand or fingers	4	
d. Wolfe grafts to palmar surface of hand or fingers	17	
e. Dermatome and razor grafts to back of hand and finger webs	23	
12. Lower Extremity—skin-grafts and other plastic operations		120
Including :		
a. Razor grafts	49	
b. Abdominal tubed pedicles	9	
c. Direct flaps	7	

## I. FACE

Three hundred and forty-six battle-casualty wounds of the face have been treated between August, 1941, and August, 1943. In 129 cases there has been so much tissue lost that skin-grafting, bone-grafting, or other types of radical plastic repair were required; whereas in the 217 other cases the tissue loss has been slight and only minor plastic procedures, such as scar excision or a simple local flap operation were required. It is our impression that the gunshot wounds of the face that heal the quickest are those that have had the least operative treatment

in the Forward Area. Treatment in the Forward Area will always be the best possible *under the existing circumstances, which those at the Base are never in position to judge, much less to criticize.*



FIG 144.—Recent gunshot wound of face sustained at El Alamein.

A few suggestions, however, for the type of treatment to be aimed at in the Forward Area, if conditions allow, may be permissible:—

a. Cleanse the wound thoroughly with hydrogen peroxide, saline, acriflavine (1-1000), or soap and water, under an anæsthetic if necessary.

b. Never excise a facial wound. Never

is recent, i.e., within twelve hours, after thorough toilet insert fine silk stitches which take small bites of the skin edge; remove these stitches within three days.

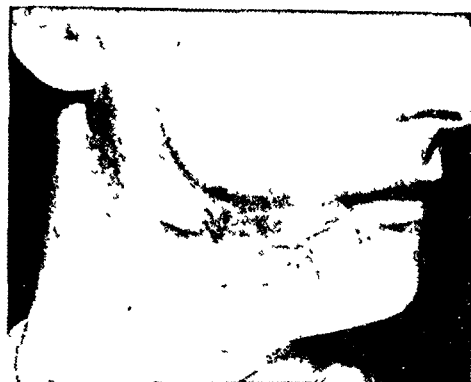


FIG 145.—The scar and deformity which occurred after 'natural healing' without any operative interference.

f. In the face, never insert a few big stitches under tension. They lead to serious septic complications and will be followed by an irreparable scar with 'cross-stitch marks' which will remain as a disfigurement for life.

On arrival at the Base hospital, practically all battle-casualty wounds of the face are infected,

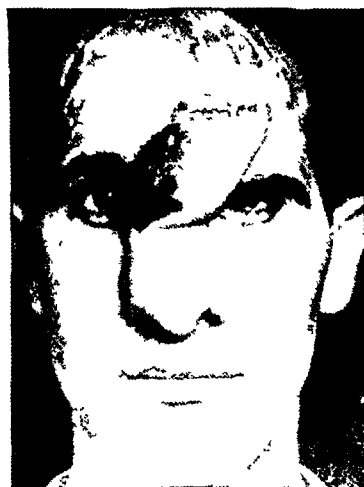


FIG 146 —Reconstruction of nose by 'up and down' forehead flap (Gillies)

perform secondary suture upon a facial wound before it has healed.

c. Save the bony framework and contour supports of the face, even if they are quite loose; only sacrifice a bony fragment if it is completely detached from all the surrounding tissues.

d. If there has been any skin-loss, pack the wound with equal quantities of sulphanilamide and sulphathiazole powder and leave it unsutured. Use tulle gras as a dressing.

e. If there has been no skin loss and the wound



FIG 147 —Nose repair by 'up and down' forehead flap

and it is advisable to apply daily dressings of sulphanilamide and sulphathiazole powder, tulle gras, and saline until the wounds have healed. Sulphonamide drugs were not given by mouth at this stage unless there was evidence of spreading local or general infection. Secondary suture of an unhealed facial wound is, in our opinion, a major surgical blunder. (Figs. 144, 145.) We have never seen a satisfactory result following such a procedure, but have been astounded on many occasions by the simplicity of the repair



required if time is allowed for the wound to heal without interference.

*a. Nose.*—A total of 135 patients with injuries of the nose have been treated during the previous two years.

*1. Deficiency or Loss of Skin Covering of Nose (14 cases).*—When the skin loss has been considerable a forehead flap repair has always been used. A classical 'up and down' Gillies flap has been used on most occasions, though sometimes when the forehead bay is wide and high, an oblique one may be preferable. (Figs. 146, 147.) Lining for the new nose is supplied



FIG. 148.—Airman with severe facial burns, showing typical eyelid deformities.

by inturned local flaps. Repair of the nose by the use of a tubed pedicle from the arm or abdomen supplies, it is true, a protrusion in the centre of the face; the resemblance to a nose, however, of these bizarre appendages is often remote and a tubed pedicle was not used if the forehead was available.

*2. Defect of Nasal Mucosa.*—Five cases with nostril stenosis have been repaired by thin Thiersch grafts, applied on stent moulds. In two cases in which there was complete atresia of one nostril, and no airway at all on one side, a new airway was supplied by this means. It is most important to maintain these new channels in a distended condition for some months by the use of hollow dilators made of acrylic resin.

*3. Nasal Bridge Depressions.*—In 19 cases bridge defects have been repaired by suitably carved iliac bone-grafts, inserted through columella-splitting or intercartilaginous incisions.

*4. Nasal Deformities without Tissue Loss.*—A total of 108 of these cases have been repaired by re-alignment of displaced skin, cartilage, and bony framework. Recent fractures with lateral displacement can be repaired easily by manipulation if seen within a week of the injury. The manipulation is carried out in three stages according to the technique described by Gillies and

Kilner: (i) Disimpaction and eversion of the comminuted nasal process of the maxilla on each side, using Walsham's forceps. (ii) The septum is straightened and the bridge line corrected by Ashe's forceps, one blade being inserted into each nostril. (iii) The nasal processes are then pressed inwards and the nose straightened.

*b. Orbit.*—

*1. Bony Margin* (2 bone-grafts to supra-orbital margin; 9 bone-grafts to infra-orbital margin).—If the bony framework of the orbit was defective it was replaced by a suitably shaped



FIG. 149.—After razor grafting all four lids.

bone-graft from the iliac crest. For repair of the supra-orbital margin an incision in the eyebrow was used. For the infra-orbital margin, if there was no scar line present on the cheek, a temporal incision was made behind the hair line, the skin of the cheek was undermined, and a suitable pocket made to hold the graft.

*2. Eyelids (35 cases—39 razor grafts, 11 Wolfe grafts, 27 local flap repairs).*—Eyelids were repaired by razor grafts fixed in position by a stent mould which was secured by silk sutures tied over it (McIndoe). (Figs. 148, 149.)

Marked over-correction is required when razor grafts are used to repair ectropion of the lids due to severe burns. The grafts should be twice the width of the apparent skin loss. This is attained by wide relaxation and by imbedding the mould in a shallow cavity. The necessary over-correction is only possible when upper and lower lids, on the same side, are grafted on separate occasions, and we believe that tarsorrhaphy is advisable in most cases. Grease massage is started about ten days after the operation, when the wound has healed, to reduce contracture and prevent 'puckering' of the graft.

Certain minor degrees of lower eyelid deficiency or deformity may sometimes be repaired successfully by an Imre's advancement and

rotation of the same lid, or by a Tripier's flap from the opposite lid. Eyebrow losses were repaired by Wolfe grafts from the same post-auricular region or by using hairy temporal flaps, the pedicle of which contained branches of the superficial temporal artery. Eye-socket defects were

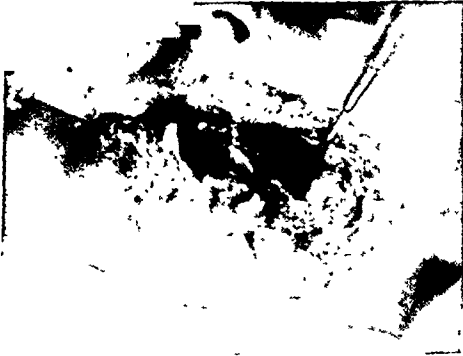


FIG. 150.—Loss of left half of lower lip and cheek due to gunshot wound. Repair by open abdominal flap turned over to form lining and covering.

replaced by epithelial inlays buried on disc-shaped stent moulds. In two cases ptosis of the upper lid was repaired satisfactorily by shortening the levator and tarsus by a modification of the von Blascovic operation.

*c. Cheek (11 cases of extensive cheek repair).—*The skin of the cheek may be replaced in various ways, depending upon the site and extent of the loss. In the most extensive, when nearly the whole of the cheek is missing, an abdominal tubed pedicle has generally to be used. The disadvantage of this method is that the colour and texture of the skin are never quite satisfactory. The central and upper parts of the cheek may be repaired more satisfactorily by a forehead flap with a temporal pedicle. In other cases a rotation flap may be used in conjunction with a Wolfe graft. The buccal lining of the cheek is replaced, when defective, by an epithelial inlay. (18 cases.)

The contour and the bony framework of the cheek were repaired by suitably shaped iliac bone-grafts. The late results of free fat-grafts have been, in our experience, unsatisfactory. Iliac bone is readily accessible and can be carved to almost any shape and provides a reliable contour replacement for most regions of the face.

*d. Lips, Mouth, and Chin (113 cases).—*

1. *Partial Losses (107 cases).—*Small skin defects of the lip can be replaced by rotation of local flaps or by Wolfe grafting from the post-auricular region or upper arm. Loss of mucosa in either buccal sulcus was repaired by thin epithelial inlays, taken from the inner surface of the arm, and held in position by a stent mould, tray, and cap splint. The 'take' of these inlays is almost certain, but it is essential to keep them dilated by suitable moulds for many weeks, as contracture will always occur unless precautions are taken to prevent it.

VOL. XXXII.—NO. 126

If a triangular full-thickness segment of lip is required as well as red margin, the Abbe method is most satisfactory (2 cases). If visible red margin only is required a rectangular flap may be turned down from the under surface of the upper lip to replace the missing red margin



FIG. 151.—Repair of left side of lower lip by open abdominal flap conveyed to the face on the opposite wrist.



FIG. 152.—Gunshot wound of face with loss of the left half of the lower lip, repaired by open abdominal flap conveyed to the face on the right wrist. Red margin repaired by rectangular flap from the under surface of the upper lip.

of the lower lip, or vice versa. Microstoma is a fairly common deformity amongst war casualties and can be repaired most satisfactorily by making a 'Y' incision at the corner of the mouth; the mouth is widened and the wound sutured in the form of a 'V', the flap of mucosa at the corner being displaced laterally to line the angle.

2. *Complete Full-thickness Loss of Upper or Lower Lip (3 cases).—*This deformity has been repaired in stages by an open abdominal flap conveyed to the face on the wrist. Finally, the red margin was taken as a direct flap from the under-surface of the opposite lip. (Figs. 150-152.)

3. In 3 other patients the loss of the lower lip and chin was extensive but incomplete, and

these were treated by rotation and transposition of local submaxillary or submental flaps associated with epithelial inlays.

*e. Ear (Figs. 153-155).—*



FIG. 153.—Total loss of right auricle and obliteration of external meatus.



FIG. 155.—Iliac bone-graft inserted for repair of right auricle.

1. *External Meatus (1 case).—*Atresia or stenosis of the external meatus was repaired, first by coring out a channel which was larger than the normal meatus and then applying a thin razor graft draped over a stent mould. Afterwards the lumen was maintained by a hollow dilator for many weeks.

2. *Partial Loss of the Auricle (13 cases).—*When the defect was wide, it was repaired by rolling forward a post-auricular flap and applying a dermatome graft behind this. When the defect was small, the available skin of the auricle itself was used to reform a normal-shaped, but rather smaller ear. It was often necessary in these cases to excise triangular segments of auricular cartilage to repair the framework.

3. *Complete Loss of the Auricle (3 cases).—*May be replaced by a prosthesis or by a series of plastic operations depending upon the preference and circumstances of the patient.

*f. Fracture of the Mandible and Maxilla (322 cases).—*Some of these had fractures of both mandible and maxilla, and in many there were two or more separate fracture sites in the mandible; in all 485 fractures have been treated.

Most of the treatment in these cases was carried out by the dental officers of the unit, Major W. H. Roberts and Capt. R. S. Pook. Classical methods, such as cap-splinting or



FIG. 154.—Epithelial inlay to repair external meatus.

occasionally intermaxillary cyclet wiring, were used in the majority of cases.

#### RESULTS OF TREATMENT OF 322 PATIENTS WITH FRACTURED JAWS

	Cases
Bony union with good occlusion	211
Bony union with defective occlusion	17
Without bony union with fibrous union or false joints	5
Transferred before treatment completed	39
Deaths	2
Still under treatment	48
Total	322

The results of treatment by the methods used by Major Roberts and Capt. Pook seem to have been highly satisfactory, especially when it is realized that a high percentage of their patients have been referred to them because the fracture involved was of the 'difficult type' and often complicated by sepsis.

*g. Malar Fracture (116 cases).—*Depressed fractures of the malar bones appear to be fairly common injuries amongst soldiers in a mechanized army. In two years we have treated 81 of these cases.

In the early stages, that is within about 10 days of the fracture, the treatment is similar in most types of displacement. A temporal incision is made behind the hair-line and the temporal fascia is opened; a Bristow's or Kilner's elevator is inserted deep to the fascia and passed under the body of the malar and often as far as the antrum. The bone is then elevated into its normal position, where it usually remains. In older cases it may also be necessary to make an incision in the upper buccal sulcus: the antrum is opened through the fracture line and the body of the malar and the infra-orbital margin are elevated through a combined buccal and temporal approach.

#### 2. NECK, TRUNK, AND GENITALIA

*a. Neck.*—There were 33 cases with severe burns and gunshot wounds of the neck. In

battle-casualty burns the neck is usually involved and contractures and webbing quite often follow. Razor grafting for these is usually unsatisfactory, but it is sometimes required in the early stages for the treatment of a granulating wound. After the wound has healed, dermatome or Wolfe grafts of considerable size have been used with success in some of the contractures of the neck. However, in the most severe type with deep scarring and severe contracture, repair by means of a tubed pedicle, carried from the abdomen on the wrist, is the most reliable procedure. If nearly all the skin on the front of the neck has been lost it is usual to raise a tubed pedicle from each side of the abdomen.

Of the gunshot wounds of the neck, there were only two in which the deep tissue loss of the anterior part of the neck was extensive, and both of these had laryngeal fistulae.

**b. Trunk.**—Twenty-five cases with primary skin loss of the chest, back, buttocks, and abdomen were repaired by skin-grafting. Secondary defects which occurred after raising direct flaps, or very wide tubed pedicles, were also repaired by skin-grafting in 17 cases.

**c. Genitalia** (15 cases, *penis and scrotum* 14 cases).—Skin loss of the penis was repaired most satisfactorily by dermatome or thick razor grafts sewn into the defect and held in position by a layer of paraffin and flavine wool with a covering splint of cotton bandage soaked in collodion. The penis was then supported on an elastoplast sling across the thighs. Potassium bromide and chloral were given for three days before and after the operation. When the urethra was involved (2 cases) the urine was side-tracked by a preliminary suprapubic cystotomy. Repair of the scrotum, where the skin is remarkably lax, was performed by rotation of local flaps.



FIG. 156.—Severe burn scarring of the hand with hyper-extensor deformities of the fingers. Treated by a direct double pedicle flap from the abdomen.

### 3. HAND AND UPPER EXTREMITY

There were 101 plastic operations to the hand and upper extremity. In the majority of patients treated, the deformity has resulted from deep burns or gunshot wounds. Skin loss of the deltoid and shoulder regions was treated by

rotation of large thick scapular flaps to cover the shoulder and thick razor grafts were used to cover the raw areas left in the posterior scapular regions. Skin loss of the axilla following burns or gunshot wounds (6 cases) has been treated by dermatome or half-thickness razor grafting; it was associated in some cases with a modified 'Z' plastic. Skin loss of the front of the elbow or wrist, the inner side of the arm, forearm, or hand (10 cases), has been repaired by direct flaps from the side of the chest or abdomen (Figs. 156, 157). It has been found that division of the base of the pedicle in two stages is advisable in most types of direct flap procedure. Under local anaesthesia half the width of the pedicle has been divided and then, after a week or ten days, the remainder of the pedicle has been separated. Results have improved considerably since the adoption of this technique.

Skin loss of the outer side of the arm, elbow, or forearm was repaired satisfactorily by a half-thickness razor graft or dermatome graft. The back of the hand is also provided with a sound skin covering by dermatome of half-thickness grafts in most cases. In about 90 per cent of the cases in which there is skin loss of the dorsum, free grafts are the most satisfactory, but in the remainder, when the scar is adherent to bone, the tendons are matted together or missing, and extreme hyperextension with subluxation of the metacarpo-phalangeal joints is present, a direct flap from the abdomen is advisable. This may be an open flap with a single pedicle or a 'bridge flap'.

The palmar surface of the hand was repaired by Wolfe grafting in 17 cases. It is important to use non-hairy skin from the abdomen or upper arm, and in many cases this is combined with rotation of a local flap. Flexor deformities of the fingers, when caused by contracture of the skin

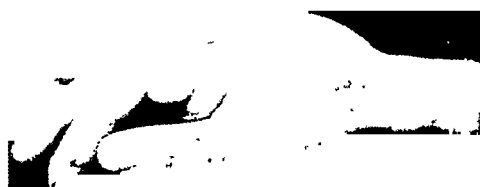


FIG. 157.—Severe burn contracture of back of hand treated by a direct abdominal flap.

and palmar fascia, may be treated by Wolfe grafting with every confidence of success. Webbing of the fingers is common after severe burns and is repaired by dermatome of half-thickness grafts held in position on stent moulds (7 cases). Tubed pedicles have been used in 2 cases for repair of the hand and in 2 cases for elongation of fingers with conical amputation stumps.

### 4. THE LOWER EXTREMITY

Operations for plastic repair of defects of the lower extremity numbered 120. Among these

there were 9 abdominal tubed pedicle repairs, 7 direct flaps, and 49 razor grafts. Superficial skin loss of the calf or thigh is repaired by half-thickness razor grafts, but if the scar is deep and adherent to bone, an abdominal tubed pedicle or direct flap from the opposite leg is necessary to ensure mobility of skin over bone. If a tubed pedicle is used, it is advisable to carry it down on the wrist or hand. In certain sites, direct flaps can be used to provide suitable skin covering; much time is saved and strong weight-bearing skin with a base of subcutaneous tissue is provided. Such weight-bearing and friction areas where an open flap can be used are:—

1. Buttock, using the wrist as intermediary for an open abdominal flap.
2. Tendo achillis region, using a direct flap from the front of the opposite thigh with the patient in the 'tailor position'.
3. Inner side of heel or sole, direct flaps from the opposite calf.
4. Outer side of the foot, direct flap from the opposite thigh or calf.

### 5. BURNS

A total of 190 cases of recent and old burns have been treated; 74 burns were due to enemy action, while 116 were accidental. The majority of the severe burns were caused by petrol accidents. Associated with the usual treatment for primary shock, a plasma infusion was given to all severe burns in which the hæmoglobin was over 100 per cent; it is usually advisable to start a continuous plasma infusion before 'cleaning up' and to continue it during the process and afterwards, until the hæmoglobin level reaches about 95 per cent. 'Cleaning up' must be gently done under a very light gas and oxygen anaesthesia, and the patient should be conscious before leaving the theatre. Whenever the burns are extensive, two or three people should work at the same time on different areas, to shorten the duration of the anaesthesia. We consider blood transfusion without venesection to be dangerous in the early stages, but obligatory in the later stages when there is sepsis and secondary anaemia. Weekly transfusions are often necessary at this stage to maintain the hæmoglobin at about 70 per cent. If very extensive raw areas are present, razor grafting during a continuous blood-drip transfusion, may be a life-saving measure at this juncture. Homografts have been used as a temporary dressing for this type of case on 15 occasions, with apparent success in 12. Venesection may have a place in the treatment of the apparently hopeless case in the stage of the so-called 'toxæmia of burns'. It is offered merely as a suggestion, because we have only used this method on one occasion, but the effect was quite dramatic.

**Salt.**—In the summer months all our patients with severe burns receive 15 gr. of sodium chloride three times a day, and they are also urged to drink at least 5 pints of fluid a day to prevent 'heat-exhaustion'.

**Dressings.**—The correct dressing for an extensive burn is still a matter of opinion and the ideal dressing is still to be discovered. There is no doubt that the widespread use of sulphanilamide powder and tulle gras has improved the results of burn treatment. There can be little doubt that air evacuation of severely burned patients has also played a major part in the saving of many lives in recent months. Patients travel more comfortably if most of the burned areas are covered with plaster-of-Paris, over the sulphanilamide and tulle gras. A closed plaster, however, should never be applied over burned hands. The minimum of dressing (i.e., sulphanilamide powder and tulle gras only) is advisable as a covering for the fingers, so that active movements may never cease. The practice of bandaging two or more fingers together is to be deprecated. Although hands and faces are never tanned nowadays, the use of triple dye for superficial but extensive burns of the trunk may sometimes prove valuable.

On arrival at the Base, the first object of local treatment is to avoid painful dressings and to prevent or eradicate infection of the raw areas by hæmolytic streptococci. If there has been extensive skin loss the ultimate aim is to prepare the patient and his raw areas for skin-grafting. These objects appear to be attained most satisfactorily by some daily bathing procedure such as:—

- a. Saline baths for the hands.
  - b. Saline irrigation of the face, using a reservoir, irrigation tube, and a 'Gillies burn collar'.
  - c. Immersion baths for the legs, arms, and trunk. Soap and water is preferable to saline when the areas are covered by sloughs or are infected by hæmolytic streptococci.
- Immersion of the whole body of a severely burned patient may be extremely dangerous if carried out too early, i.e., during the first, second, or third week. We have seen severe dehydration, protein loss, and toxæmia following too early bathing.

It is wise to start baths on alternate days, and to watch the effect of this before starting daily immersion. This does not apply to hand baths, which should be started after the first 24–48 hours; active movements of all joints of all fingers are started at once, both in the baths and between them. (Figs. 158, 159.)

**Burns of the Back.**—Patients with extensive burns of the back of the trunk and legs should be nursed in the prone position on a sorbo mattress. Extensive trunk burns, and especially those of the back, are extremely dangerous. In the four burn patients who died, the back of the trunk was involved in each.

**Eyelids.**—When both eyelids are burned, early razor grafting and tarsorrhaphy under local anaesthesia may be required as an emergency to prevent corneal ulceration and blindness. If ectropion has become established the granulating

or scarred areas near the lid margin must be incised, the lids freed, and the elliptical raw areas thus produced are grafted. Only in this way can the lids be approximated without tension on the tarsorrhaphy stitches. The patient must be

communicating, the wall of each is defined, sutured, and an intervening layer of omentum is used to separate them. If the omentum cannot be brought down on a pedicle with its own blood-supply, a sheet of omentum is excised and applied



FIG. 158.—Hooped exerciser. Finger exerciser. A padded anterior cock-up splint is provided with a metal hoop hinged at the level of the wrist and adjustable in position by two finger screws. The patient's fingers can be exercised in most positions by altering the position of the hoop. The fingers are attached to the hoop by elastic bands and wash-leather slings.



FIG. 159.—Finger exercises. Elastic finger and wrist for extensor deformities. The plaster slab was hinged on the back of the wrist and a section of bicycle tyre was incorporated in the plaster. Metal antlers were also incorporated for the attachment of rubber bands for finger exercising.

warned to use grease and massage for three months after the burned areas have healed. It is also important to support the limb when dependent by firm bandaging, otherwise multiple subcutaneous hæmorrhages will occur and chronic cyanosis with small areas of ulceration may follow.

#### RESULTS OF TREATMENT OF 190 CASES OF EARLY AND LATE BURNS

	Cases
a. Returned to unit	104
b. Evacuated to United Kingdom or South Africa	63
c. Still under treatment	19
d. Deaths	4
Total	190

#### 6. "THE THREE-LAYER REPAIR" OF FISTULÆ

The general principles to be adopted in the repair of fistulæ are similar wherever they occur. To be certain of occlusion, a fistulous tract should

##### TYPES OF FISTULÆ TREATED

	Cases
a. Bucco-nasal	14
b. Bucco-antral	8
c. Naso-cutaneous	4
d. Orbito-nasal	1
e. Mastoid	3
f. Frontal sinus	3
g. Urethral	2
h. Laryngeal	2
i. Parotid	7
Total	44

be repaired by accurate definition and suture of three layers. If the fistula is from a mucosa-lined viscus to the surface, the mucosa, an intervening layer of connective tissue, and finally the skin, are defined and three separate layers are sutured. Inside the abdomen, if two viscera are

over the wall of each viscus as a free omental graft. This 'three-layer' principle has been employed successfully in 37 cases with various types of fistulæ in our plastic surgery of the past two years in the Middle East.

#### COMPLICATIONS

1. **Sepsis.**—All battle-casualty wounds have been infected to a varying degree, but, as most of the wounds were inflicted in the comparatively sterile environment of the desert, the septic complications have been relatively benign. Most have responded well to ordinary treatment by the sulphonamide group of drugs and a very restricted quantity of penicillin. Hæmolytic streptococcal infections acquired after the patients have reached the various Base hospitals have been disappointingly high.

2. **Secondary Hæmorrhage.**—Seven cases of secondary hæmorrhage have been treated. Nevertheless, it appears that there has been a much lower incidence of secondary hæmorrhage associated with the Middle East jaw injuries in this war compared with those in Flanders in the last war. This is assignable to the reduced incidence of severe sepsis. Both external carotids have been tied in the 4 cases where there was bleeding from inaccessible parts of the face. Bleeding stopped immediately, but on one occasion a partial right hemiparesis and temporary aphasia followed. This case is important, as perusal of the literature would suggest that ligation of both external carotids is an absolutely safe procedure. As in this patient the bifurcation of the carotid and the facial branches were clearly defined on each side before the external carotids were tied, embolism through the internal carotid seems the most likely explanation. The aphasia

and the hemiparesis disappeared completely after about one month and the patient returned to his unit as a fit man. We believe that hemiplegia following even common carotid ligature is comparatively rare in young patients, but when it occurs it may be due to embolism\* in some cases and not always to primary capillary anæmia. In another patient, however, attacks of respiratory spasm were almost certainly due to an error in surgical technique, the right superior laryngeal nerve having been included in a ligature around the external carotid.

#### TYPES OF PATIENTS TREATED IN RELATION TO OCCUPATION, NATIONALITY AND SEX

	Cases
<b>Males.—</b>	
<i>British and Empire :</i>	
Army, Navy, Air Force, and Merchant Navy	1085
<i>Allied Nations</i>	44
<i>Prisoners of War :</i>	
German	15
Italian	35
<b>Females.—</b>	
W.A.A.F.'s, A.T.S., Nursing Services, etc.	21
	<u>1200</u>

#### RESULTS IN THE FIRST 1200 PATIENTS TREATED BY NO. 2 MAXILLO-FACIAL UNIT IN THE MIDDLE EAST

	Cases
Returned to unit fit for duty	862
Evacuated to United Kingdom or South Africa	190
Transferred to other Special Centres (e.g., Neuro-surgical, Orthopaedic, or Genito-urinary) for treatment of associated injuries	40
Still under treatment	100
Deaths	8
<b>Total</b>	<u>1200</u>

One of the 8 patients who died had crush anuria, 3 had gunshot wounds of face with multiple associated injuries, and 4 died from the effects of severe burns which involved the back of the trunk as well as the limbs and face. Of these, 3 died during the first or second week from 'burn toxæmia', and as they were jaundiced before death they probably died from liver deficiency. The fourth died during the sixth week from sepsis which was a sequel, we believe, to too early bathing.

### DISCUSSION

During the last few years some progress has been made in the treatment of the maxillo-facial type of war casualty. The main factors to which we ascribe this progress are :—

\* G. H. Makins [*Brit. J. Surg.*, 1915, 3, 353] reported three cases in which hemiplegia was delayed and occurred 5, 11, and 15 days after ligature of the common carotid. Max Page described a case in which arterial embolism occurred on the fifth day, and caused partial hemiplegia.

a. Air evacuation has been increased and greatly improved.

b. Improvement in the application of the sulphonamide group of drugs.

c. The efficiency of the blood and plasma transfusion units in the Forward Areas.

d. Intratracheal anæsthesia with pentothal induction.

e. External pin-fixation in the troublesome fractures of the mandible and malar.

### SUMMARY

1. A preliminary review of the 1200 cases treated by a Maxillo-facial Unit in the Middle East during a period of two years is presented.

2. A short survey of the methods used for the treatment of the commoner types of injury is given.

3. Some impressions on the treatment of 190 cases of severe burns are given. The back of the trunk was involved in all the four patients who died from the effects of burns.

4. Rapid venesection of 3½ pints and replacement by transfusion of fresh and stored blood was used in the treatment of one patient suffering from severe 'burn toxæmia', associated with intractable vomiting and persistent hiccup. The patient recovered.

5. The importance of air evacuation, burn centres, external pin-fixation for certain facial fractures, and a rigid dressing technique is emphasized.

6. A short description is given of some of the complications that have occurred amongst these patients; crush anuria and traumatic aneurysms of the common carotid, femoral, and brachial arteries are mentioned.

No bibliography has been included owing to the inaccessibility of works of reference. We should, therefore, like to acknowledge our gratitude to all plastic surgeons and their original writings, and especially are we indebted to the works and teaching of Sir Harold Gillies and Mr. T. Pomfret Kilner. I am indebted to my colleagues, Major W. R. Roberts, Capt. M. H. Shaw, Capt. R. S. Pook, and to Capt. A. W. Raffan and Capt. F. G. Mackintosh, my anæsthetists; also to my ward sister, Miss E. E. Seager, for her untiring devotion to her patients. Of all, perhaps, I owe the greatest debt of gratitude to the loyal co-operation of my team orderlies, Cpl. C. G. Dowse, Ptes. G. Davies, J. T. Maltby, W. S. Morgan, A. T. Weymouth, and S. Bennett. I am grateful to Capt. G. D. Matthew for his help in the writing of this review.

I wish to thank the Consulting Surgeons, Middle East, Major-General D. C. Monro and Major-General W. H. Ogilvie, for permission to publish this brief review.

## SECOND THOUGHTS ON THE ABDOMINAL SURGERY OF 'TOTAL' WAR—A REVIEW OF OVER 1300 CASES\*

By GORDON GORDON-TAYLOR

THE heartening results of the treatment of abdominal injuries of war to-day have been attained not only through the admirable skill and judgement of the surgeons, but also thanks to the wondrous organization for blood transfusion throughout all the Services at home and on the seas, by the exploration and discriminating employment of the now lengthy saga of sulphonamide drugs, and finally, owing to the foresight and wisdom of all who have so splendidly and co-operatively planned and administered from the Directorates of Medical Departments and Medical Headquarters of the various Services. The value of penicillin, especially for those injuries which accompany abdominal wounding, is inestimable.

I would fain have dealt with some novel problem in this Hunterian Lecture; in the words of Lucretius, "*invatque novos decerpere flores*"—it is pleasant to pluck fresh flowers. But to-day the exigencies of war, the travail of travel, and the ceaseless Sisyphean struggle against the headlong tide of Time preclude the contemplation of much else than that which pertains to war and the wholehearted prosecution of this great conflict to a successful conclusion, and towards the attainment of a lasting peace. With this self-confession and request for indulgence in my selection of a former theme I take comfort in the words of Sir Thomas Browne in the *Dedicatory Epistle to Hydriotaphia* (Urn Burial), written three hundred years ago: "We are coldly drawn into discourses of Antiquities, who have scarce time before us to contemplate new things, or make out learned novelties".

Two years and more have elapsed since the delivery of my Bradshaw lecture which dealt with over 600 abdominal casualties in this 'total' war; since that occasion through the kind offices of my many friends in this island I have been kept informed of many, perhaps most, of the abdominal injuries due to enemy activity over this land, and also of many of the abdominal wounds and lesions incidental to the activities of troops in training, or associated with the 'black-out' and other circumstances of 'total warfare'. I have also collected and considered many of the abdominal injuries of naval warfare, and I have had opportunities to observe and even to operate in E.M.S. hospitals on some Army casualties in the later stages of their convalescence from abdominal wounds sustained in the Mediterranean area.

Furthermore, a number of communications on this subject with amazingly low mortality

percentages have recently appeared in the medical press. Some of these already published figures from Africa I have utilized for this Lecture; on the other hand, save for purposes of comparison, I have not drawn upon the material presented by Major-General W. H. Ogilvie in his most valuable contribution published in a recent number of *Surgery, Gynecology and Obstetrics*. This comprehensive and beautifully written article on "Abdominal Wounds in the Western Desert" contains a characteristically charming tribute to those who worked under his ægis on both shores of the Mediterranean. His wizardry of words, his wealth of imagery, the abundance of his information, and the wisdom to be learned therefrom prompt the usage of those lines employed long years ago by King Alcinous of the Phæacians to another great warrior-traveller in the Middle East, the mighty Ulysses himself:

σοὶ δ' ἐπὶ μὲν μορφήν ἐπέων, ἐνὶ δὲ φρένες ἐσθλαί  
—*Odyssey*, Book XI, 367.†

It is chiefly around the comparative mortality-rate of operations for the abdominal wounds and injuries of this war before and since March, 1942 (Bradshaw Lecture), that the interest of this lecture is centred. I confess that I had been a little envious of the fine percentage of recovery in abdominal cases reported from the Mediterranean area, and it was most stimulating to find how closely recent figures from E.M.S. sources and from abdominal casualties in H.M. ships capable of undergoing operation ashore approximated those of the Army surgeons in Africa.

Table I.—ABDOMINAL INJURIES  
OF TOTAL WAR

Cases of abdominal injury reported in Bradshaw lecture, March, 1942	610
Recovery	312
Percentage recovery	51 per cent

Table II.—ABDOMINAL INJURIES  
OF TOTAL WAR

Total operations for abdominal injury under review since March, 1942	708
Recovery	422
Percentage recovery	60 per cent
Improvement in recovery-percentage in the second period of war	9 per cent

Table III.—ANALYSIS OF ADDITIONAL  
CASES SINCE MARCH, 1942

Cases from E.M.S. hospitals, etc.	252
Recoveries	156
Percentage recovery	62 per cent
Certain cases already published by Army surgeons in medical press	331
Recoveries	198
Percentage recovery	60 per cent

\* A Hunterian Lecture delivered at the Royal College of Surgeons of England, May 19, 1942.

† But upon thee is grace of words, and within thee is a heart of wisdom.



Table IV.—CERTAIN NAVAL ABDOMINAL CASUALTIES

Operations ashore on Naval abdominal casualties received in H.M. ships	52
Recoveries	32
Percentage recovery	61.5 per cent
Operations on Naval casualties for underwater explosion	73
Recoveries	36
Percentage recovery	50 per cent

## THE CIRCUMSTANCES OF ABDOMINAL WOUNDING

The passage of time only adds to the number, variety, and multiformity of the circumstances of abdominal wounding; the mechanisms and environment of injury are as numerous "as autumnal leaves that strow the brooks in Vallombrosa". A certain amount of information was vouchsafed in my Bradshaw Lecture on such matters as the relationship of the abdominal injuries of 'total' war was to age, sex, pregnancy, parturition, etc. The 6-cm. fetus recorded in that lecture is probably still the youngest authenticated victim of Hun 'hate'.

Two cases of abdominal injury have recently come under my notice where the victim has been in the pregnant state or the throes of parturition. In J. L. Stephen's successful case a 7-month pregnant uterus was torn open by a large glass fragment; the child only survived three days. Not many months ago Valentine Blake, of Yarmouth, performed a successful operation for wounds of the feminine cæcum produced by glass fragments from bomb blast during the earliest days of a woman's puerperium.

Some women have suffered injuries of abdominal structures peculiar to their sex; one patient, indeed, died of multiple injuries, including severe hæmorrhage from the uterine artery. A girl of 17 fortunately recovered from abdominal damage, comprising nine perforations of the small intestine and lacerations of the right ovary and Fallopian tube as well as the right cornu of the uterus; the ovary and tube required removal.

Maternal protection may fail to save the offspring from enemy missiles; in one Northumbrian mortuary lay a child with a ghastly abdomino-thoracic wound still clasped in the embrace of its dead parent, rigor mortis conserving this last act of motherly love like some piece of idyllic statuary.

More fortunate was the girl of 14, whose 'boy friend' had his arm around her waist; a fragment of an anti-aircraft shell produced a through-and-through wound with fracture of the youth's right ulna, and tore a wound in the right loin of the girl, traversed her right kidney and came to rest in the retroperitoneal tissues. His arm doubtless saved her from more serious visceral damage. (G. F. Langley's case.)

**Abdominal Injury from Pebbles.**—Pebbles driven through a wound of the loin by the explosion of a land mine divided the left kidney in half and lacerated the descending colon of a soldier.

The left paracolic sulcus was a quarry of stones and hard faecal masses; the kidney was removed and the colon sutured. The wounds of the parietes and the left arm were in a pultaceous state and healing was protracted. Recovery took place. (W. H. Bullen's case.)

The detonation of a mine blew a signalman from the port wing of the bridge of one of H.M. ships on to the after-gun on the boat deck, a distance of some 30 ft.; a second explosion blew the man into the sea. Subsequent events cogently determined a laparotomy, and Surgeon Lieut. John Ferguson, R.N.V.R., found the spleen disrupted and the abdomen full of blood. The man's recovery from an urgent splenectomy performed ashore under most disadvantageous conditions seemed assured, but unfortunately, circumstances necessitated the surgeon proceeding to sea on operational duties, leaving the patient on a foreign shore under the supervision of Italian attendants little acquainted with the value or technique of gastric suction (!); a promising case ended badly.

**"With His Pants Down".**—A leading steward in one of H.M. ships was at the "heads" when the ship struck a mine; he sustained a non-penetrating injury of the inguinal region, which bled very profusely.

At the same moment a stoker caught in a similar predicament was flung up and came down on a broken seat, receiving a wound traversing the ischio-rectal fossa, dividing the levator ani, and exposing the peritoneum in the depths of the cavity. Both men recovered.

**Immersion Blast.**—This subject has been fully and ably discussed with illustrative cases by many writers, notably Wakeley et al., Rex Williams, Hay and Gill, Simmons et al., d'Abreu, Martin, and others.

**Air Warfare.**—A lieutenant of the U.S. Air Force was hit by cannon fire from an enemy fighter over France; he sustained two wounds in the right iliac fossa and two in the upper part of the right thigh. There was a rent 2½ in. long in the cæcum and ascending colon; eight perforations were found in the lower ileum. He had also a compound fracture of the elbow and some superficial lacerations of the thorax. His convalescence from an operation by J. H. H. Gough, of Chichester, was complicated by an intestinal volvulus due to a band, but the officer eventually made a complete recovery.

Charles Noon, of Norwich, successfully operated upon an R.A.F. officer who had been wounded by enemy aircraft; a severe kidney injury necessitated a nephrectomy.

A Flying Officer wounded over France brought his aircraft safely back to the aerodrome; he had several wounds of his small intestine; he recovered. (Air Vice-Marshal Geoffrey Keynes.)

A Navigating Officer of the U.S. Air Force was brought down in the sea by anti-aircraft fire. He was picked up by a rescue launch and on admission to hospital was found to have a wound

above and to the right of the symphysis pubis. After a transfusion of 3 pints of blood, laparotomy was performed. An injury to the branches of the mesenteric vessels at the point where they enter the wall of the bowel had produced a large intramural blood extravasation almost completely occluding the intestinal lumen. Resection appeared to hold out most promise of a smooth recovery; this line of treatment yielded an excellent result (A. E. Wynne's case). (National War Collection.)

**The W.A.A.F. and the Balloon Barrage.**—A W.A.A.F. while engaged in getting a barrage balloon into the air during a raid was struck by a fragment of bomb-casing measuring 2 in. by 1 in. This had divided the left gastro-epiploic artery and produced a rent in the anterior wall of the stomach. She made a good recovery. (J. A. McLaughlan's case.)

Most of the abdominal injuries of total war have been sustained in the **performance of duty**. I have already recorded the story of the milkman milking the cow with complete non-chalance during an air raid; he was hit in the buttock by a bomb splinter which penetrated his abdomen and gored in front by a heifer at the same moment.

**Mars and Venus** flirt to-day as in mythological times. A charming girl turned a revolver upon her own body—*cherchez deux hommes*—the bullet drilled a neat hole in the liver, tunnelling the lower part of the organ and emerging through its quadrate lobe. No other viscus was damaged; the girl made a good recovery. (H. L. Gervis's case.)

**Penetrating Abdominal Wounds in Two Casualties produced by the same Missile.**—The following were operated on by Surgeon Commander Frank Stabler, R.N.V.R., at a Naval Shore Establishment.

**Case.**—O, Seaman J. F. C. received a bullet wound 7 hours before operation. Wound of entry through upper part of right rectus abdominis and of exit just below tip of 11th right rib. Lower half of right kidney contused; laceration of liver bleeding. Recovery.

**Case.**—O Seaman W. C. was hit by same bullet as J. F. C.; the track was almost in the same line, but about 1 in. lower. The bullet was probably deformed by impact on the rib of J. F. C., and entry and exit wounds were large and ragged. At operation, laceration of transverse colon found with much soiling of the peritoneal cavity. Suture. Caecostomy. Death from septic peritonitis. Contusion of right kidney and suprarenal found at autopsy.

**Penetrating Wound of Rectum and Bladder due to Impalement on a Broom Handle.**—

**Case.**—A broom handle penetrated the rectum of a soldier standing on the apex of a pyramid of tins in his effort to attach some object to a wire roof-high. A slip of the foot led to a perforation of the anterior rectal wall and the base of the bladder. Molesworth repaired the wounds transvesically with a 'boomerang' needle. The man made a good recovery.

**Kicks from comrades, male or female, have ruptured the masculine gut; D. H. Patey successfully operated on a soldier with an injury of the ileum produced by this form of trauma. In this casualty the point of application of the violence appeared to be the root of the penis, perhaps the natural goal for the energies of revengeful sex.**

**Curiosity or Bravado and Abdominal Injury.**—A boy played too often with a bakelite bomb; his right hand and forearm were found on the roof of a neighbouring building, his caecum was lacerated, and the sight of both eyes was lost. An exteriorization-operation was performed on the right-sided colon: the opening was subsequently closed. The abdominal result gave complete satisfaction. (A. R. Jordan's case.)

**Speed.**—The cult of speed has led to millions of days lost from duty, to serious disablement and to death. A motor-cycle accident produced a rupture of the posterior half of a soldier's diaphragm, followed by suppuration above and below the midriff. The man recovered after three months' desperate illness. (Major R. E. Isaac's case.)

A tragic case was that of a soldier who 'gated-crashed' into the Dieppe expeditionary force in



Fig 160—Small fragments of bomb casing which entered buttock and produced many wounds of small intestine (L. C. Rivett's successful case.)

the autumn of 1942; he returned safely, but two days later was struck in the belly by the steering wheel of the vehicle which he was driving and which was involved in a car smash. His pancreas was torn right across and the third part of the duodenum ruptured. He perished.

The perils of the 'black-out' are familiar to all. Bladders have been ruptured by weary men falling out of upper tier bunks while asleep; some have ruptured their spleen in a similar manner; even the intestine has been torn.



FIG. 161.—Intestinal resection necessitated by injuries produced by fragment, 6 in.  $\times$  4 in.; weight, 8 oz. (See Fig. 168.) Death. (Major Margaret Salmond's case.)

**Size of Missile.**—In this present conflict a successful issue does not often result in the case of those injured by a large fragment or missile. Even in the war of quarter of a century ago a man struck in the abdomen by a piece of metal of any size rarely survived, and the author's successful case of a man injured in the belly by a fragment of shell weighing a quarter of a pound with frightful resultant injuries was one of the exceptional cases which emphasize the truth of the assertion made above. Most of the successful cases of abdominal injury in this war have been due to missiles of small size (Fig. 160). Major Margaret Salmond's casualty damaged by a large jagged fragment of metal, measuring 6 in. by 4 in. and weighing half a pound, was scarcely likely to repay the skill and intrepidity of the surgeon (Figs. 161, 168). Milnes Walker's successful case suffered abdominal injuries from a fragment measuring  $2\frac{1}{2}$  in. by 1 in. by  $\frac{1}{2}$  in. A. R. Jordan, of Dover, operated successfully on an abdominal case injured by a fragment 2 in. by 2 in. Donald Barlow's successful intestinal resection (National War Collection, No. 97) (Fig. 162) concerned a man hit by a fragment of bomb-casing measuring about  $2\frac{1}{2}$  cm. by 1 cm. and weighing about  $\frac{1}{2}$  oz.

Where the dramatic in the abdominal surgery of war is told, the name of Richard Charles, of Ipswich, always finds an honoured place. Fig. 163 is a radiograph of a successful case where a fragment of cannon-shell was removed from the pelvis of Flying Officer K., by this surgeon; the foreign body measured 1 in. by  $1\frac{1}{4}$  in. There were two large lacerations of the pelvic colon, and several non-perforating lesions of the small gut. A severe wound at the root of the penis was also present.

**Bayonet Wounds of the Abdomen.**—Two successful cases were recorded in my Bradshaw Lecture (J. S. Horn, Major Anthony Till). More recently, other successes have come under my notice, such as Surgeon Commander Long's case of a bayonet wound of the transverse colon in a Marine. R. S. Vick had a successful case, where a soldier impaled himself on a bayonet which perforated bladder and rectum; the other abdominal viscera escaped injury. Another case was met with during a 'practice casualty run' in a hospital in the County Palatine, where one of the mock casualties on a stretcher attracted attention

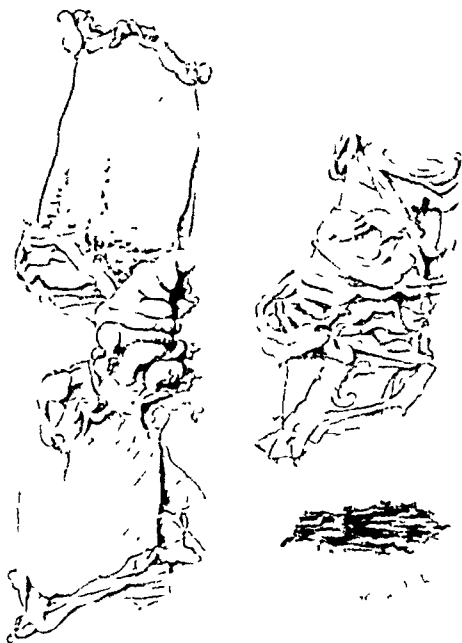


FIG. 162.—Successful resection of small intestine damaged by fragment of bomb casing,  $2\frac{1}{2}$  cm.  $\times$  1 cm.; weight,  $\frac{1}{2}$  oz. (Donald Barlow's case.)

by reason of his pallor and poor condition. Reality to the proceedings had been secured by a comrade prodding the patient in the side with a bayonet. The weapon produced a right-sided abdomino-thoracic wound, involving the lung, diaphragm, and liver. Fortunately the man recovered.

N. J. Townsley's case in Norwich of a bayonet wound in the belly was fortunate in that no abdominal viscus was injured.

Glass has again assumed an important role as a wounding missile (Vaughan Hudson, Patey, Nockolds, Stephen, and others) amongst civilian casualties.



FIG. 163.—Portion of cannon-shell which produced two large perforations of pelvic colon and several incomplete tears of small bowel. (Richard Charles's successful case.)

**Immunity of Viscera.**—Surgical exploration of the abdomen in the present war and that of 1914-18 has proved beyond refute the occasional immunity of viscera in penetrating and perforating wounds of the abdomen, even when the missile must have traversed the 'intestinal area'.

**Subminimal Injuries** of the abdominal cavity and contents. These are naturally of infinite variety. In the material under review there have been such bizarre lesions from penetrating injury as a wound of a single appendix epiploica, or a through-and-through wound of the falciform ligament of the liver with a resultant intraligamentous hæmatoma. Abdominal signs sufficient to call for an exploration may reveal only a small hæmoperitoneum trickling through from a more extensive retroperitoneal extravasation (D. H. Patey).

## LESIONS OF INDIVIDUAL VISCERA

**Extrusion of Abdominal Contents.**—The first successful operation for intestinal laceration in the last war concerned a Canadian who recovered from a 6-ft. resection of herniated bowel.

(Owen Richard's famous case of March 18, 1915.) In my Bradshaw Lecture I showed that recovery-rate of extruded undamaged intestine due to enemy missiles was 50 per cent, but of damaged herniated bowel only 20 per cent survived. Eversionation is therefore a serious complication of wounding.

Squadron Leader W. P. Griffin, R.A.F., had a successful case where most of the small intestine, the cæcum and appendix, and a large portion of the rectum had prolapsed through a wound of the belly and were lying over the pubic region and between the thighs, supported only by the man's trousers. Fortunately the only visceral damage sustained was an abrasion involving a length of  $3\frac{1}{2}$  in. of ileum. The wound of the parietes was extensive and much ingenuity was required to reconstitute a covering for the abdominal contents.

A rating was stabbed in the left flank by a sailor of an allied Navy. Six feet of small gut had herniated through the wound; a small perforation of the jejunum was sutured and a tear of the mesentery treated by Surgeon Lieutenant-Commander O. J. Vaughan-Jackson, R.N.V.R. The man made a good recovery.

**Number of Perforations of the Intestine submitted to Operation.**—In my Bradshaw Lectures I quoted the successful case of A. L. Ledingham, who sutured 16 rents in the small bowel. Since then, pride of number of perforations of intestine among the cases coming within my ken appears to belong to S. E. Duff, of Grimsby, who successfully sutured 20 perforations of the small gut. Despite these excellent results, the successful cases are usually those in which lacerations are few and suitable for repair by suture.

**Successful Extensive Resections of Small Intestine for Injury.**—The successful bowel resections are still those of limited extent, but there are a few noteworthy exceptions. Surgeon Captain D'Arcy's successful 6-ft. resection of small intestine in a sailor wounded afloat by an incendiary bullet, which was recorded and illustrated in my Bradshaw Lecture, has been equalled by a successful resection of a similar length of small intestine by J. B. Kinmonth of St. Thomas's Hospital.

**Case.**—A man was hit in bed by an explosive-incendiary; he was admitted to hospital pulseless with badly shattered intestine herniated through a large rent in the hypogastric region of the abdomen. A resection of at least 6 ft. of bowel was performed; the condition of the man was so desperate, despite the pre-operative transfusion of many pints of blood and plasma, that the operation was hastily terminated by bringing the two ends of the small intestine to the surface. The continuity of the alimentary tract was restored after two days. The patient ultimately made a splendid recovery.

Douglas Freebody successfully resected 4 ft. of purplish devitalized small gut herniated through a weak laparotomy scar which on the night of an 'incident' the patient had not protected by the belt which he normally wore.

The agency was a 'blast' mechanism, for no foreign body was found at operation or on subsequent radiography. The man also had

Major Margaret Salmond successfully removed 3 ft. of small intestine damaged by a mortar bomb; the piece resected contained



FIG. 164.—Triple resection of small intestine in patient suffering from multiple severe injuries. (Sol. M. Cohen's case.)

a wound of the cæcum. A. G. Ross, of Chichester, also successfully resected 4 ft. of ileum.

*Case.*—A girl was crushed between two army lorries; a portion of the ileum was completely detached from its mesentery and at the time of operation was already green and stinking. The cæcum was badly damaged, exteriorized, and removed at a later date.

eight perforations. There were also two tears in the mesentery of the colon.

Lieut. Colonel Kergin, C.A.M.C., had a successful 3-ft. resection of a herniated small intestine in a Canadian wounded in the Dieppe raid of 1942.

**Double Resections of Bowel.**—Very little attention has been paid to double resections of bowel in this conflict. Perhaps these are so

banal and the results so uniformly satisfactory that comment appears unnecessary (!); on the other hand, perhaps cases that require double resection are so seriously injured elsewhere as to be past all surgical aid.

During the last war I performed 22 double resections of bowel, of which 11 recovered. In my Bradshaw Lecture I quoted Mayrick Thomas's successful quadruple resection of intestine, which was complicated by a wound of the bladder. Recently H. W. L. Molesworth, of Folkestone, saved a quadruple resection of small bowel damaged by enemy action (National War Collection); the portions resected measuring each about 10 to 12 in. in length. Buttery, also of Folkestone, had a successful double resection of small intestine and sigmoid flexure, the patient only coming to operation over 24 hours after injury.

Sol. M. Cohen's beautifully performed triple resection (Fig. 164) failed to save an air-raid victim, who subsequently died from his many other injuries, which included the loss of the whole of the horizontal ramus of the mandible with its superjacent integument. Molesworth's double resection of bowel in a desperately wounded air gunner—small bowel and transverse colon (Fig. 165) (National War Collection, No. 367) ended fatally.

A year ago Colonel Loyal Davis of U.S.A. Medical Service told me of an Officer of the American Air Force recovering from a double resection of bowel for injuries sustained in aerial combat.

Recently E. K. McLean, of Shoreham, had a successful double resection of small intestine in a soldier who was wounded in the buttock by a bullet which involved the abdominal cavity. The left testicle also required removal.

**Injury to Meckel's Diverticulum.**—The only case of an injured Meckel's diverticulum in this war of which I have knowledge ended fatally.

I recorded a successful case of an injury of this type which I operated on during the Fifth Army Retreat of 1918; the specimen was mounted in the Museum of the Royal College of Surgeons until its destruction in 1941.

Even subparietal injuries of a Meckel's diverticulum are very infrequent, although Gamble described a case, where a man was struck by the handle of a plough.

Alexander Innes operated on the following patient presenting the signs of a blast injury to the abdomen from the explosion of an anti-tank grenade.

**Case.**—The patient showed signs of a blast injury of the lungs as well as the belly and had extensive superficial burns of the arms, legs, and chest. At laparotomy a loop of the lower ileum showed a gangrenous area extending on to the mesentery; this

gangrenous area was found to implicate a diverticulum which was split on either side, permitting the leakage of bowel contents. The wall of the gut itself was normal. The patient died three days later from causes unconnected with the abdominal injury or the bowel excision performed. (N. C. 147.) The diverticulum had not the characters of a Meckelian process.

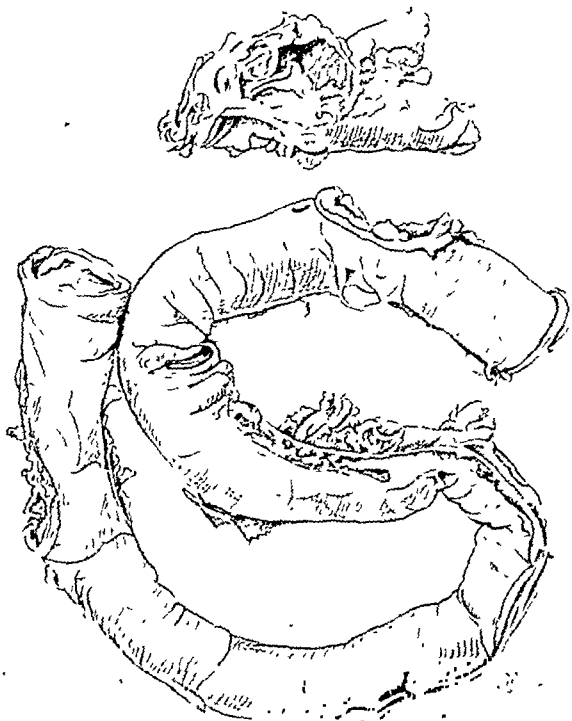


Fig. 165.—Resection of small bowel and transverse colon. Fatal issue. (H. W. L. Molesworth's case.)

Table V.—ANALYSIS OF SMALL-INTESTINE INJURIES

276 out of 708 total abdominal operations for abdominal visceral injury, i.e., 39 per cent.
Compare: 43 per cent in Bradshaw series, 1942,
39 per cent in Sir Cuthbert Wallace series, 1918,
30.4 per cent in Major-General W. H. Ogilvie's series (1944).
Recovery rate: 174 out of 276 cases of small-intestine injury.
Percentage recovery = 63 per cent
Compare: Bradshaw series (1942) 47.3 per cent
Sir Cuthbert Wallace series (1918) 37.5 per cent
Major-General W. H. Ogilvie's series (1944) 62 per cent

Table VI.—INJURIES TO THE LARGE INTESTINE

Operations where abdominal injury is confined to small intestine	130
Recoveries	91
Percentage recovery	70 per cent
Compare: Bradshaw series (1942)	64 per cent
Sir Cuthbert Wallace series (1918)	42 per cent
Major-General W. H. Ogilvie's series (1944)	63 per cent

**Exteriorization of the Wounded Colon** is now *à la mode*; the technique is sponsored by the experience of many surgeons in this conflict and now advocated in handbooks and memoranda.

Yet in experienced hands the wounds of the large gut may often be confidently sutured and the colon even resected without recourse to extrusion tactics. Inspector-General Fruchaud, Consulting Surgeon to the Free French Force, had four consecutive successful resections of the right-sided colon for severe injury, a direct anastomosis being performed between ileum and transverse colon; Mrs. Toland, F.R.C.S., of Dover, had a successful resection of the hepatic flexure with an end-to-end junction. Myriads of successful intra-abdominal sutures of the lacerated colon have been performed in this war. For example, H. G. Thomas successfully sutured a wound of the descending colon 6 in. long—a resection of small gut (National War Collection) was also needed; J. H. Cobbe, of Dover, successfully sutured two lacerations of the splenic flexure; and R. Vaughan Hudson two wounds of the hepatic flexure produced by glass, etc. etc.

Nevertheless, in many contused and lacerated wounds of the colon, exteriorization has proved a life-saving measure, and the adoption of this technique has led to an improved recovery-rate in a type of visceral injury far more serious than small-bowel lesions.

It is necessary, however, thoroughly to mobilize the sessile segment of the colon which requires exteriorization. Where this has been inadequately performed and the colon 'dragged' to the surface, and the laparotomy wound has given way, the colon may recede to the recesses of the abdomen; the result is then dire and baleful indeed. Where this unfortunate accident befalls a right-sided colonic exteriorization, the discharge of faecal stream, pus, etc., may severely dehydrate the patient, excoriate his skin, and engender suicidal impulses in the unfortunate victim of surgical failure. Paul-Mikulicz procedures on the right side of the belly sometimes may prove a burden scarcely to be borne. For lacerations of the *transverse or left-sided colon* it is a measure of safety and the means of saving countless lives.

Table VII.—INJURIES TO THE LARGE INTESTINE

231 out of 708 total abdominal operations for abdominal visceral injury, i.e., 32.6 per cent	
Compare	Bradshaw series (1942) 27 per cent
	Sir Cuthbert Wallace series (1918) 26.1 per cent
Recovery rate 129 out of 231 cases of colon injury	
Percentage recovery = 56 per cent	
Compare	Bradshaw series (1942) 40 per cent
	Sir Cuthbert Wallace series (1918) 42 per cent
	Major-General W. H. Ogilvie's series (1944) 61 per cent

Table VIII.—OPERATIONS WHERE ABDOMINAL INJURY IS CONFINED TO COLON

	78 cases	
	Recoveries, 49	
	Percentage recovery, 62.8 per cent	
Compare	Bradshaw series (1942)	45 per cent
	Sir Cuthbert Wallace series (1918)	41.3 per cent
	Major-General W. H. Ogilvie's series (1944)	60 per cent

**Injuries of the Urinary Bladder.**—The cases in my series call for little comment. The subject has been discussed in the valuable paper by Sandrey and Mogg, who (1) emphasize the importance of primary closure of wounds of the bladder which are just as urgent as lacerations of the alimentary tract; (2) urge suprapubic draining of the bladder; and (3) demand drainage of the extravescicular cellular spaces.

**Injuries to the liver** may be protean in character; five huge rents in the liver with a huge hæmoperitoneum were found in an airman who crashed; a neatly drilled hole in the quadrate lobe was all the damage received by a lady 'playing' with a revolver.

In the National War Collection (N.C. 361) there is a specimen exhibiting an area of ischaemic necrosis of the liver in relation to a large internal rupture of the organ. The man had been struck on the back by an aeroplane landing on a runway. At operation, there was no external evidence of a ruptured liver. A tear of the duodenum was successfully sutured and had no share in the causation of death which did not take place till eleven days after the accident. (Wing Commander Cato's case.)

**Injuries of the Gall-bladder and Bile-duct.**—The anatomical position of the gall-bladder renders it unlikely to be the sole viscus injured by any penetrating wound. Guthrie and Baron Larrey held the opinion that gall-bladder wounds were mortal, effusion of bile into the cælotomic cavity being in their experience a fatal issue. The organ seems to bear a charmed existence in more recent warfare, since in my Bradshaw series of over 600 cases of abdominal injury investigated in the present conflict, I found the records of only 2 patients with gall-bladder injury. Though one of these cases was complicated by many injuries to many organs and other parts of the body, the woman recovered; the other patient died from the severity of concomitant damage to other parts.

A woman recovered from an abdomino-thoracic wound produced by a fragment of glass; the diaphragm, liver, and gall-bladder were perforated. The wounds of the gall-bladder were sutured, and a cholecystostomy performed (H. Nockolds).

There was only one specimen of a penetrating wound of the gall-bladder in the War Collection from the last conflict of 1914-18 which was lodged in the Royal College of Surgeons' Museum till its destruction by enemy action; the patient is said to have died of peritonitis, but the liver and kidney were damaged as well, and there is no statement that it was a biliary peritonitis that caused death.

Most interesting of all is the case of a bullet in the gall-bladder quoted by Guthrie a century ago as having occurred in the practice of M. Huttier of Chalons-sur-Marne; a soldier was hit by a musket ball in the right side; the bullet was retained and was found two years later post mortem within the gall-bladder.

In the National War Collection (Temporary No. 43) is a liver from a fatal right-sided abdomino-thoracic injury due to a bomb fragment  $\frac{1}{2}$  in. in diameter (Fig. 166). The fragment injured liver and gall-bladder, and bruised the stomach.

**Injury of the Main Hepatic Duct.**—A successful case of operative repair of a complete



FIG. 166.—Fatal right-sided abdomino-thoracic injury due to bomb fragment; injuries to liver, gall-bladder, and stomach.

division of the hepatic duct just below the portal fissure has already been recorded in a previous number of the *BRITISH JOURNAL OF SURGERY* by J. H. Park, of Brighton. The patient, a Marine, was injured by a fragment of bomb aboard a 'flak-ship' during the Dieppe raid of 1942 and is well to-day.

The operation of cholecystectomy unfortunately still provides the most frequent occasion for reparative operations on the main bile-duct; despite vague reference to the treatment of gunshot injuries of the hepatic or bile-ducts I can find no authenticated report of a successful case akin to that of Park.

The Bradshaw Lecture contained the report of a case in which blast injury to the chest and abdomen was thought to have implicated the main bile-duct (J. H. Buttery's case). This case recovered after secondary evacuation of 8 pints of bile from the coelomic cavity.

### PENETRATING ABDOMINO-THORACIC INJURIES

In the recent series there were 90 cases of penetrating injury of both thoracic and abdominal cavities; this figure represents 12.5 per cent of all abdominal casualties and corresponds almost exactly with the 12.7 per cent of my Bradshaw Series (1942). This percentage also corresponds very closely with the 12 per cent in Sir Cuthbert Wallace's series in the last Great War and with the 11 per cent recorded by Douglas Jolly in the Spanish Civil War.

The indications for operation in these cases have been dealt with elsewhere by myself and other authors; I have been flattered by the inclusion of my own views on this problem in the recent *Field Surgery Pocket Book* issued by the War Office. The problem may to-day perhaps be epitomized succinctly thus: (a) the immediate mortality in abdomino-thoracic injuries is almost invariably due to the wound of the thoracic viscera, e.g., heart, hilum of the lung, etc.; (b) those reaching a surgical unit are more likely to perish from wounds of the abdominal viscera, and as a general rule laparotomy is more likely to save life than thoracotomy. Laparotomy and timely aspiration of the hæmothorax will save most lives in this group of casualty. The large lacerated thoracic wound which so cogently demanded excision in the last war in France and Flanders and insensibly led to primary thoracotomy has been infrequently met with in this series up to the time of the Normandy Invasion; the large fragment travelling with many times the velocity of a quarter of a century ago kills to-day; most of the abdomino-thoracic cases that have been submitted to surgery to-day have been casualties produced by small fragments.

The recovery rate of penetrating abdomino-thoracic wounds in the more recent group is somewhat lower than in the Bradshaw Series—55.5 per cent as against 63 per cent.

The experience of this conflict confirms the findings of the last Great War that the prognosis of abdomino-thoracic wounds is more favourable when solid abdominal viscera are injured. Many such cases are to be found in the series under review: for example, Surgeon Commander Keating (spleen, liver); Surgeon Lieutenant Nicks (several successful nephrectomies); John Everidge (kidney, specimen National War Collection).

*Case.*—A rating in one of H.M. destroyers received a penetrating abdominothoracic wound on the left



side. On admission to a shore establishment the casualty showed evidence of considerable intra-peritoneal hæmorrhage. Laparotomy; peritoneum full of blood and blood-clot; many of the splenic vessels divided at the hilum and lower pole of spleen also damaged. Splenectomy. Recovery. (Surgeon Commander Keating.)

*Case.*—A delicate boy with a double aortic murmur, with a strong personal and family history of epilepsy. Despite 193 days' sojourn in hospital during his time of Service, the youth pluckily contrived to get aboard one of H.M. destroyers and received a severe right-sided abdomino-thoracic wound in action. The abdominal injuries comprised two tears of the small gut, a rent of the liver, and a laceration of the mesentery. Despite his previous history, the casualty made a good recovery. (Surgeon Commander Claude Keating's case.)



FIG. 167.—Fatal case of abdomino-thoracic wounding. Fragment of bomb embedded in wall of œsophagus

The story of wounds of the œsophagus is not unnaturally dispiriting (*see Fig. 167*, National War Collection. I am informed, however, that Lt.-Colonel A. L. d'Abreu has actually saved a man wounded in the thoracic œsophagus, which must rank as one of the most splendid triumphs of surgical prowess.

The story of the case whose heart is shown in the National War Collection (No. 384) is somewhat unusual. A bombardier sustained an abdomino-thoracic wound of the right side; the wound of entry was in the right 8th intercostal space without fracture of any rib. Laparotomy disclosed 2 pints of blood in the cœlom; there was a lacerated dome of the liver on the right side. Patient's condition was good; the anæsthetic was ethyl chloride followed by ether administered by the Oxford vaporizer. Duration of anæsthetic was

forty-eight minutes. Twenty-four hours later the patient suddenly and most unexpectedly collapsed and died. Post mortem; a metallic foreign body  $\frac{1}{2}$  in. by  $\frac{1}{2}$  in. by  $\frac{1}{2}$  in. was found to have traversed the liver, diaphragm, and antero-inferior aspect of the right auricle. The fragment was lodged in the origin of the right coronary artery, and was projecting into a sinus of Valsalva. No effusion of blood was present in the pericardium; the small clot adherent to the wall of entry in the right auricle had effectively sealed the aperture!

### 'THE TRAVELLING TRANSFUSION'

This arresting term emphasizes the inestimable value of blood in the treatment of abdominal cavities, and the frequent necessity for administration between the Ambulance and the Forward Surgical Unit. It is gratifying to find that a practice of mine, once somewhat derided, now merits the approbation of military surgeons, since nine years have passed since I warmly advocated its employment during the transportation of cases of bleeding peptic ulcer to hospital, and quote cases where 'travelling transfusion' has been performed in ambulance, train, etc. for distances up to nearly 100 miles from London. As a pre-operative measure in certain abdominal injuries the 'travelling transfusion' has been invaluable. The inventive genius and enthusiasm of your faithful surgeons have organized measures that surpass the more embryonic efforts of my loyal henchmen a decade ago.

### MISTAKES IN DIAGNOSIS

*Necessity for Thorough Examination.*—The necessity for cleansing and the most thorough examination of the patient should not require re-affirmation to-day. The back and buttocks must not escape attention.

*Case.*—A woman had suffered discomfort in the right iliac fossa for 24 hours while she was walking homeward *during an air raid on a Scottish city*, the pain in the belly suddenly increased and her general condition rapidly deteriorated. She was later admitted to hospital with diagnosis of acute appendicitis or a leaking duodenal ulcer! The nurse in the course of cleansing operations discovered a small wound in the right anterior left flank, the latter oozing blood. Her condition never permitted operation. Post-mortem examination revealed wounds of colon, pancreas, and vena cava.

*Injuries from Enemy Action as an Aid to Diagnosis.*—In my Bradshaw Lecture commented upon a case where a sliver of glass penetrating a previous abdominal scar determined a second laparotomy and led to the substitution of a diagnosis of inoperable cancer of the stomach by that of a pancreatic cyst!

There have been other instances where diagnosis had been made in this indirect manner.

*Case.*—A patient of Wilson Hall, of Eastbourne, had two wounds of the sigmoid flexure successfully sutured. Wounds of the thorax suggested radiological methods of examination, and *achalasia of the cardia* was demonstrated in the patient.

*Case.*—*Left-sided abdomino-thoracic wound* and carcinoma of the proximal end of transverse colon.

A soldier received a wound low down in the left thorax. Abdominal signs determined a laparotomy; a large retroperitoneal hematoma was found surrounding the spleen and left kidney, and involving the left end of the transverse colon and its mesocolon. The abdominal incision was closed. Three attacks of "abdominal ileus" occurred during his early convalescence and later during the stages of his evacuation to the United Kingdom.

A fourth attack of obstruction decided a surgeon to "look inside"; a carcinoma of the proximal end of the transverse colon was discovered and excised by the Paul-Mikulicz technique, but without much vigour. In England he came under the care of Sol. M. Cohen with a large-bowel fistula surrounded by a considerable recurrence of the growth in the bowel and surrounding abdominal wall. Cohen performed a fresh colon excision with end-to-end suture and removed the abdominal parietes widely. The man remains free from recurrence to-day.



FIG. 168.—Large fragment of metal removed from patient with frightful abdominal injuries. Weight 8 oz. Death. (Major Salmond's case.)

### 'THE SECOND OPERATION'

A second operation for an abdominal injury within a few hours of the first demands fortitude in decision and awakens grave anxiety. I mentioned two such cases ending happily in my Bradshaw Lecture (Sir Ernest Rock Carling, T. W. Mimpriss). More recently another successful case has been dealt with by R. Wilberforce Smith.

*Case.*—Soldier, 18, extinguishing an explosive incendiary, received a ragged penetrating wound in the right loin. Wound excised; posterior aspect of the ascending colon and lower pole of right kidney exposed; foreign body removed from behind these structures. No injury to peritoneum discerned. Six hours later abdominal symptoms seemed to

urgently demand laparotomy; a few ounces of blood-stained fluid were found in the right paracolic sulcus; there was a small puncture on the lateral side of the ascending colon and a small tear in the adjacent liver. No sign of any tear in the parietal peritoneum could be found that had been overlooked at the first operation.

**Late Complications of Abdominal Wounding.**—The patient who survives the primary dangers of abdominal wounding and the gastric dilatation and ileus which constitute such



FIG. 169.—Right lobe of liver riddled with multiple thick-walled abscesses. Death occurred several months after wounding, and in the interval the man had appeared well.

a familiar feature of post-operative progress to convalescence to-day may succumb to still later complications and sequelæ. A specimen in the National War Collection (No. 140) (Fig 169) shows the right lobe of the liver riddled with multiple thick-walled abscesses; in addition, the right main branch of the portal vein contained old organized clot which appeared to be infected, though not yet necrotic. The man had been injured on the right side by a mortar-bomb splinter which damaged the right kidney and the bowel in the region of the cæcum; the date of wounding preceded death by several months, and in the meantime the man had appeared well.

Amongst the disquieting and dangerous sequelæ of abdominal wounding are certain fistulæ of the alimentary canal. These may develop in patients who have been left unoperated

for various reasons; they may endanger the lives of those with a right-sided colonic wound in whom exteriorization had been imperfectly carried out; all the resources of surgery will probably fail to save the lives of those in whom the right-sided colon has been dragged to the surface without adequate mobilization and has receded with still open lacerations within the flank, bathing the



FIG. 170.—Small-intestine fistula resulting in a "Dunkirk Evacuation" abdominal case treated expectantly. Subsequent resection of the fistula. (B. C. Maybury's successful case.)

depths of the wound, the skin, and perhaps a damaged hip-bone in an unceasing tide of excoriating and purulent liquid (*see above*).

Such fistulae may also result from secondary perforation of intestinal coils exposed in breaking down laparotomy wounds (Fig. 170). (National War Collection, No. 90.)

**Secondary Hæmorrhage** occasionally besets the journey to convalescence of the abdominal casualty. In the present series it has been most often met with in cases where the wound of entry or exit has been situated in the perineum or buttock. A soldier shot through the abdomen at close range had his sacrum and rectum completely shattered. Various perforations of the small intestine were sutured and a colostomy performed. There were serious wounds of his lower limbs, in one of which gas gangrene was present, ultimately determining amputation. Recurrent secondary hæmorrhages from the rectal area have been of torrential character, and nearly 100 pints of blood have been employed in preserving the life of this man. (C. K. Warrick's case.)

The steady crescendo in the recovery-rate from operations for abdominal wounding throughout these five years of war is indeed inspiring, while comparison of modern figures with the results obtained during the conflict a quarter of a century ago affords eloquent testimony that despite the greater multiplicity and complexity of the injuries of total warfare, the severity of

wounds, the increased velocity of missiles with greater maiming effects, the multifarious congeries of victims of different sex, age, and physique, surgery has far greater power to heal and to save than ever before.

Ideals may be for pursuit and not for attainment, but he would be bold indeed who ventured to foretell that in this province of surgery the zenith of our achievement has yet been attained; already, indeed, the recovery-rate in the hands of a few individual surgeons, whom Luck has perhaps brushed with her wings or who may have been blessed in the matter of environment or fortunate in other ways, has been of almost astronomical magnitude. There is much, therefore, to substantiate the claim of the young surgeon\* that in the treatment of abdominal casualties of war he has surpassed his teachers and the previous generation of war surgeons. *Macte virtute, puer, esto. Sic itur ad astra.*†

The sketches illustrating this paper have been drawn from specimens now assembling in the National War Collection sponsored and organized by the Medical Research Council. For permission to make use of these I am under a debt of obligation to that Council, and I am also grateful to Mrs. Muriel Wright, who has faithfully and skilfully depicted these trophies of surgical endeavour. The hope is entertained that the presentation of these illustrations and the indication of their source may remind those who may be furnished with the opportunity to earn the gratitude of present and future surgeons by adding to that material from which a shrewd and discerning selection will eventually be made for permanent display.

Finally, the material for this lecture could never have been accumulated had it not been for the loyal co-operation of many friends aware of my interest in this branch of surgery. To them this Lecture is dedicated as a mark of my esteem, admiration, and gratitude.

#### BIBLIOGRAPHY

- FRUCHAUD, Inspector-General (1944), private communication.  
 OGILVIE, W. H. (1944), *Surg. Gynec. Obstet.*, March.  
 GORDON-TAYLOR, G. (1942), *Brit. J. Surg.*, 30, 7 et seq.  
 — (1935), *Lancet*, 2, 811.  
 — (1936), *Brit. J. Surg.*, 18, 78.  
 — (1939), *Med. Pr.*, Oct. 18.

\*In the early weeks after the Normandy Invasion the recovery-rate of the abdominal injuries attained the magnificent figure of 70 per cent; in some British hospitals a recovery-rate of even 80 per cent was obtained from operations for abdominal wounds, a figure which coincides with that given by Colonel Elliott Cutler amongst American Forces in his recent Linacre Lecture. *C'est magnifique.*

† Well done! young man, that is the way to glory.

## ISCHÆMIC NERVE LESIONS OCCURRING IN VOLKMANN'S CONTRACTURE

BY W. HOLMES,\* THE LATE W. B. HIGHET, AND H. J. SEDDON

DEPARTMENT OF ORTHOPÆDIC SURGERY (PERIPHERAL NERVE INJURIES CENTRE), AND DEPARTMENT OF ZOOLOGY AND COMPARATIVE ANATOMY, OXFORD

It has long been known that serious lesions of peripheral nerves are commonly associated with Volkmann's contracture, producing a paralysis more extensive than that due to direct muscle damage alone. This was pointed out very clearly in 1909 by J. J. Thomas, who also surveyed the earlier literature. It was thought possible that treatment of these nerve lesions might result in considerable amelioration of the disability. From his review Thomas concluded that the nerve lesions resulted either from actual division of the nerve-trunks or from secondary compression of the nerves and their branches by shrinkage of the ischæmic muscles—"for compression of the nerve-trunks there seems no need to despair . . . freeing of the nerve-trunks, the placing of them away from the contracting muscles under the skin, and at times the resection of a portion of the nerve and its suture . . . affords us the choice of methods of great promise." It is not the purpose of this paper to discuss cases of Volkmann's contracture accompanied by straightforward division of main nerve-trunks since the treatment of such cases, *qua* nerve injury, is no different from that appropriate in uncomplicated nerve division. The puzzling cases are those in which there is no evidence of division and, as Thomas pointed out, the desirability of finding the treatment appropriate in these cases is very great since there is not only a paralysis due to ischæmia of muscle but also complete loss of sensory and motor function in the hand or foot. The first step is to elucidate the pathology of the nerve lesions and then to determine whether any form of treatment is likely to be of value.

During the past two years a number of cases of established Volkmann's contracture have been investigated at the Oxford Peripheral Nerve Injuries Centre. The following account is of the investigation of six of them in which there was gross damage to peripheral nerves resulting from the ischæmia; in every case the upper limb was affected. These cases were subjected to full clinical and operative investigation and specimens of muscle and nerve were removed for histological examination. The nerves showed an unusual type of pathological change which is believed to be due to ischæmia, and the characteristics of which have a direct bearing on the prospect of recovery.

The diagnosis of established ischæmic paralysis is usually depressingly simple and there is

often no need for the elaborate ritual carried out in each of these cases. Nevertheless, the technique employed to obtain the data required by this investigation merits description, since some or all of the examinations will be found of value in elucidating cases in which the diagnosis is not obvious at first sight.

### OUTLINE OF INVESTIGATION

#### A. Signs of Vascular Obstruction.—

1. Examination of pulses.
2. Oscillometry with Pachon's (or similar) apparatus.
3. Skin temperature measurements (*see C* (4) below).
4. Arteriography.
5. Inspection of vessels at operation.

#### B. Signs of Damage to Muscles.—

1. Clinical examination.
2. Percutaneous electrical stimulation.
3. Electromyography.
4. Injection of perabrodil into the affected muscle and radiographic observation of the time of absorption.
5. Biopsy.

#### C. Signs of Damage to Nerves.—

1. Clinical examination: motor, sensory, and sudomotor.
2. Percutaneous electrical stimulation.
3. Electromyography.
4. Skin temperature measurements.
5. Nerve exploration and biopsy.

Some of these investigations, and also the order in which they are performed, call for comment.

*Skin temperatures* were measured with thermocouples and galvanometer before and after heating other parts of the body.

*Arteriography*.—Perabrodil (50 per cent) was used, but although the pictures obtained were reliable, the radiographic contrasts were not as satisfactory as those obtained by the method that we learned later from Professor J. R. Learmonth (personal communication). Most of our pictures required touching up for reproduction, whereas this is not usually necessary after Learmonth's technique, which, unfortunately, was unknown to us at the time when these cases, except the last, were investigated.

The following technique is based on his recommendations and on those of Dr. F. H. Kemp, who is now in charge of the X-ray department at the Wingfield-Morris Hospital. For arteriography in the upper limb general

\* Beit Memorial Research Fellow.

anæsthesia is necessary; but for the lower limb spinal anæsthesia is better, since it produces great vasodilatation which will be well established half an hour after the injection of the anæsthetic. The vessel is exposed through a short longitudinal incision, preferably as high as possible, so that all proximal branches will be made visible radiographically. Disturbance of the artery in its bed must be avoided, since this may cause spasm. A 10-c.c. syringe is used, filled with strong perabrodil or diodone, with an eccentric nozzle and a fairly large needle, e.g., No. 19 Record for the femoral artery. It is important to keep the bevel of the needle down as it enters the lumen of the vessel. Large quantities of perabrodil have been used without harmful effects (Learmonth has used 10 c.c., followed within a few minutes by a second injection of the same quantity), but occasionally severe reactions occur in patients subject to allergic conditions: asthmatics, in particular, tolerate the drug badly. If it is thought desirable, the patient can be tested beforehand by placing 0.5 c.c. of perabrodil in the mouth for five minutes. A susceptible patient will show swelling of the mouth and tongue. The severe reactions are acute pulmonary or laryngeal œdema and, if noticed early, can be checked by the administration of adrenaline.

The plunger is pressed as rapidly as possible and the signal for exposure given just before the syringe is emptied. Exposure factors are of little value; it is best to work them out for the individual case from films taken prior to arteriography. Kemp recommends a hard flat film, obtained by incorporating filters in the tube. The needle is then withdrawn quickly and pressure made on the vessel for two minutes with a moist swab. If it happens that the site of block is obscured by the bone shadow there is no objection to repeating the injection almost immediately.

**Electromyography** (Weddell, Feinstein, and Pattle, 1943).—This method of diagnosis was not available at the time when this investigation was made, but more recent experience has shown its value in ischæmic as well as in other forms of muscle change. Large action potentials are characteristic of motor units in normal muscle; small irregular action potentials of the fibrillation of denervated muscle; whereas in completely ischæmic paralysis there is no electrical activity of any kind.

**Injection of Perabrodil into Muscle.**—It was found by one of us (H. J. S.) that when perabrodil is injected into muscle the rate of absorption (as seen radiographically) is very much slower from ischæmic than from normal or denervated muscle. (See Case 2.)

**Sweat Secretion.**—Guttman's (1940) method was used.

The order of investigation was as follows:—  
Clinical examination:

motor, sudomotor and sensory,  
vascular and skeletal,  
percutaneous electrical stimulation, (electromyography),  
oscillometry,  
(injection of perabrodil into affected muscles).

Operative examination (one session):

arteriography,  
fullest possible exposure of nerve, electrical stimulation,  
if convenient, exposure of damaged vessels,  
biopsy of affected muscles and of small cutaneous and muscular nerves.

The exposure, although extensive, must be planned with some caution, so far as blood-vessels are concerned, so as to avoid damage to the collateral circulation, on which the nutrition of the limb may be entirely dependent.

### CASE REPORTS AND PATHOLOGICAL INVESTIGATIONS

The nature of the injuries responsible for the vascular damage has been summarized in Table I.

Table I.

CASE No.	INJURY	NERVE LESION
1	Closed fracture of the radius and ulna	Complete median and ulnar paralysis: partial radial paralysis
2	Closed fracture of the mid-shaft of the humerus	Complete median and ulnar paralysis in the hand: partial radial paralysis.
3	Bomb-splinter wound of the lower third of the arm	Complete median and ulnar paralysis in the hand: no radial paralysis.
4	Fracture of the surgical neck of the humerus	Complete median and ulnar paralysis in the hand (complete motor paralysis of all the intrinsic muscles, with depression of all cutaneous sensibility and sweating): partial radial paralysis
5	Closed fracture of the lower end of the radius	Complete median and ulnar paralysis in the hand: partial radial paralysis
6	Closed fracture upper third of radius and ulna	Incomplete median, ulnar, and radial paralysis.

Since they are not strictly relevant to the subject of the paper, no details are given about bone injuries and their treatment; about fractures and their treatment; or the histological changes in muscle.

**Case 1 (C.1).**—A soldier born in 1906.

Feb. 25, 1941: Thrown off an army lorry and sustained fractures of the outer end of the right clavicle, body of the right scapula, and upper third of the right radius and ulna. He lost consciousness and remembers nothing of the accident. Admitted to hospital elsewhere: notes scanty, but state that "There was obvious displacement and fracture of

both bones of the right forearm. The radial pulse was absent, and the hand was blue and cold. There was no sign of any circulation in the right hand. The forearm was manipulated under anesthesia: the radial pulse returned, but it was still very weak. The arm was put in plaster. At no time did he complain of pain in the forearm or hand.

March 12: Admitted to the Wingfield-Morris Hospital.

Aug. 27: Exploration of nerves, muscles, and vessels; arteriogram.

#### PRÉCIS OF FINDINGS.—

##### Vascular Damage.—

Pulse at wrist half as forcible as on normal side.

Oscillometry: Greatly reduced pulsations in lower third of forearm (Fig. 171).

Skin temperatures: No reflex vasodilatation in hand (Table II).

Arteriography (Fig. 172): Brachial and ulnar arteries patent; radial artery obliterated in upper third of forearm opposite site of fractures (cf. normal arteriograms, Fig. 173).

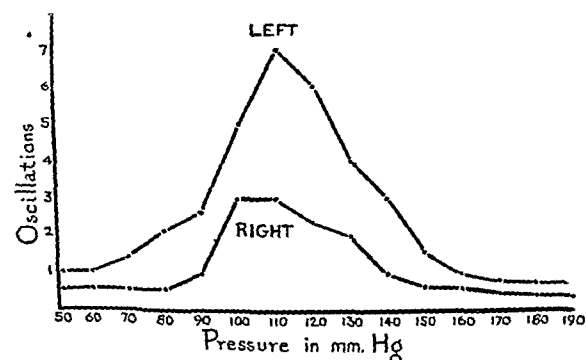
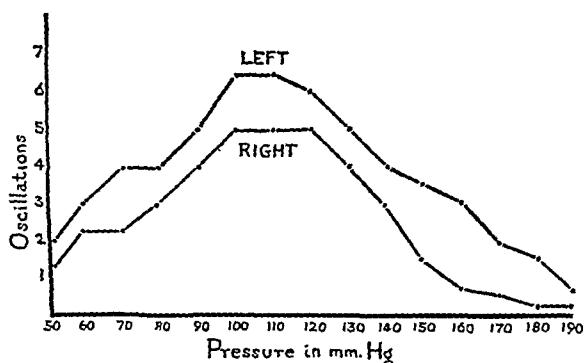


FIG. 171.—Case 1. Oscillometric records from normal and affected limbs: above, in the upper half of the forearm; below, at the wrist.

Direct inspection: Subcutaneous veins and small arteries more numerous than usual, in contrast with paucity of both in deeper layers. Normal pulsation

in brachial artery; venæ comites apparently larger than normal. Pulsation also seen in both ulnar and radial arteries.

Table II.—MEASUREMENTS OF SKIN TEMPERATURE IN DEGREES CENTIGRADE, MADE AT VARIOUS POINTS ON THE RIGHT AND LEFT HANDS AT ROOM TEMPERATURE AND AFTER HEATING. ROOM TEMPERATURE 21° C.

	AFTER 30 MIN. EXPOSURE TO ROOM TEMPERATURE		AFTER EXPOSURE OF LIMB IN A HOT-AIR CHAMBER			
	Right	Left	Right	Left	Right	Left
Digit tips	21	31	22	33	23.8	34
Centre of palm	26	32	27.5	33.5	28.5	35
Front of wrist	26.3	32	28	33.5	29.2	35
Mid forearm	29.3	32.5	31.4	33.5	32	34.5
Front of elbow	30.3	33.5	32.3	34	34	35.5

#### Muscle Changes.\*—

B. Rad.  
E.C.R.L.  
All other muscles in forearm  
Muscles of hand

##### Appearances at Operation:

Proximal 3-4 cm. of common flexor origin normal; otherwise complete necrosis of flexor group. Necrosis of lower third of extensor group, except E.D.C., which was fibrotic and yet responded to faradism.

Voluntary Power  
Faradic Response  
Galvanic Response

##### Histological Changes:

P.T. Necrosis.  
E.D.C. Slight degeneration.  
A.P.L. Necrosis.  
F.D.P. Necrosis.  
F.C.U. Necrosis.

Nerve Damage.—Complete sensory loss and anhidrosis of median and ulnar distribution (Fig. 174); paralysis of intrinsic muscles of hand. At exploration, median nerve of normal diameter (5 mm.) above elbow. At a point 6 cm. below the medial epicondyle it passed between the two heads of pronator teres where it was constricted by scar tissue, diam. only 2 mm.; below this, diam. 3 mm. No neuroma. Nutrient vessels visible as far down as

#### \* Abbreviations used in describing muscles:—

Radial: B. Rad. Brachioradialis  
E.C.R.L. Extensor carpi radialis longus  
E.D.C. Extensor digitorum communis  
E.Min.D. Extensor minimi digiti  
E.C.U. Extensor carpi ulnaris  
A.P.L. Abductor pollicis longus  
E.P.L. Extensor pollicis longus  
E.P.B. Extensor pollicis brevis  
E.I. Extensor indicis  
Median: P.T. Pronator teres  
F.C.R. Flexor carpi radialis  
P.L. Palmaris longus  
F.D.S. Flexor digitorum sublimis  
F.P.L. Flexor pollicis longus  
F.D.P. Flexor digitorum profundus  
P.Q. Pronator quadratus  
A.P.B. Abductor pollicis brevis  
O.P. Opponens pollicis  
F.P.B. Flexor pollicis brevis  
Ulnar: F.C.U. Flexor carpi ulnaris

constriction, but below it nerve appeared avascular and fibrotic. Faradic stimulation: response in upper few centimetres of pronator teres and flexor carpi radialis.

which a relatively short period had elapsed between injury and exploration, and in view of the re-innervation of the degenerate nerve. The connective tissue of the nerve was well supplied



FIG. 172.—Case 1. Arteriogram. The ulnar artery is patent, but the radial artery is scarcely to be seen. It is probably obliterated near the level of the radial fracture. The anastomotic circulation around the elbow is heavily outlined. Below the level of the fractures there are only a very few fine blood-vessels.



FIG. 173.—Two normal arteriograms. Perabrodil was injected into the brachial artery midway between the axilla and the elbow. The radial, ulnar, and anterior interosseous arteries are well outlined. The anastomotic circulation around the elbow is faintly visible. In the forearm many fine arterial branches are outlined.

with small blood-vessels: many of these were surrounded by aggregates of polymorphonuclear leucocytes and lymphocytes, but the inflammatory reaction was not severe.

Ulnar nerve normal above elbow, not examined in upper forearm; at 10 cm. above wrist, shrunken, diam. 1.5 mm., fibrotic. No response on stimulation.

#### HISTOLOGICAL EXAMINATION OF NERVES.— a. Anterior Interosseous Branch of the Median.—

This branch contained many myelinated nerve-fibres, but was abnormal in that none of the fibres had a total diameter of more than 4.5  $\mu$ , as measured in paraffin sections stained by Weigert's method; most of them were considerably smaller. Many small aggregates of myelin breakdown products are visible among the fibres, and an abnormally large number of Schwann nuclei is present. It may be concluded that the fibres were in process of regeneration after an initial Wallerian degeneration of the whole nerve. In one respect, however, the changes in the nerve are not typical of Wallerian degeneration, for there has been a considerable thickening in the collagenous endoneurium which separates the density of the tubes. Such an increase in the density of the endoneurial connective tissue is known to follow Wallerian degeneration when a nerve stump is left denervated for very long periods (Holmes and Young, 1942), but it was not to be expected in this case, in



FIG. 174.—Case 1. Complete sensory loss and anhidrosis of median and ulnar distribution. Partial sensory loss and anhidrosis in the lower part of the distribution of the medial cutaneous nerve of the forearm.

b. *Branch of the Median to F.D.S.*—The two bundles of nerve-fibres of which this branch is composed showed a degeneration entirely unlike the Wallerian type. They contained no nuclei of any kind, either Schwannian or mesodermal, and in the Weigert preparations the myelin of the fibre sheaths is seen to be broken up into irregular masses occupying the whole thickness of the fibre (Fig. 175, 176). This myelin change is unlike that of Wallerian degeneration in that no phagocytic cells are present



FIG. 175.—Case 1. Transverse section of one bundle in the branch to F.D.S. Weigert-alum carmine. Scale =  $40\mu$ .

and the products of sheath degeneration are not collected into the characteristic 'digestive chambers' formed by the cytoplasm of the macrophages. And similarly there has been none of the shrinkage of the lumen of the tubes characteristic of degeneration after simple division, with the result that the fibres have retained their normal uniform diameter of about  $14\mu$ . One of the bundles shows endoneurial oedema, but there is no sign of a cellular inflammatory reaction in any part of the specimen.

c. *The Dorsal Cutaneous Branch of the Ulnar.*—The nerve-fibres in this branch were completely degenerate, their axons and myelin having disappeared entirely except for a few scattered droplets of broken-down myelin. There has also been a great increase in the collagen of the endoneurium. The endoneurium is represented by thick dense strands of

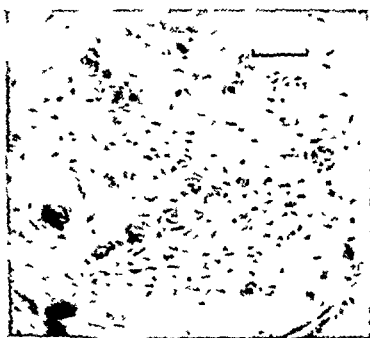


FIG. 177.—Case 1. One nerve-bundle from the dorsal cutaneous branch of the ulnar. Transverse section. Weigert-alum carmine. Scale =  $40\mu$ .

macrophages of Wallerian degeneration, though others are smaller, and some have nuclei of abnormal shape (Fig. 178). It seems likely that all these cells are phagocytic, and that some of them are disintegrating: there are none that can certainly be identified as

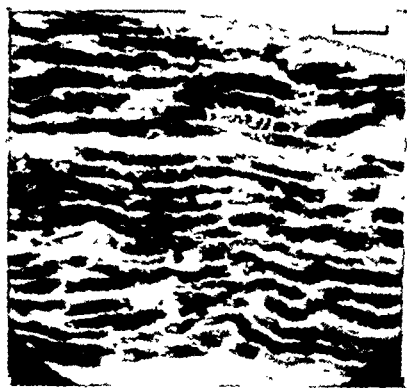


FIG. 176.—Case 1. Same nerve as in Fig. 175, longitudinal section. Weigert-alum carmine. Scale =  $40\mu$ .

Schwann cells. Numerous small vessels containing normal blood are present both in the endoneurium and perineurium: they are probably more numerous than in the normal state, and represent part of the collateral circulation of the limb developed in response to the arterial obstruction.

SUMMARY.—The degeneration of the fibres in the anterior interosseous branch of the median nerve cannot have been due to the constriction of the main trunk between the heads of pronator teres, since the branch arose well above the site of constriction. It may possibly have been due to trauma at the time of the original injury, causing axonotmesis followed by regeneration. On the other hand, the presence of endoneurial thickening, which is not typical of Wallerian degeneration, inclines one to suggest that the initial fibre degeneration, accompanied by endoneurial thickening, was due to ischaemia caused by centripetal vascular spasm at the time of injury. ¶ The



FIG. 178.—Case 1. Same nerve as in Fig. 177. Longitudinal section. Masson. Scale =  $40\mu$ .

subsequent regeneration of the fibres, in progress when the specimen was excised, must have resulted from revascularization, without which growth of fibres could not have occurred.

The condition of the branch to F.D.S. seems to be a necrosis comparable with that of ischaemic infarction of muscle: there is no cellular reaction, the nuclei of all cells in the nerve have disappeared, and there has been some autolytic breakdown of the myelin. The

collagen with sparsely distributed nuclei; consequently in many areas in the nerve the Schwann tubes representing the original fibres have been completely obliterated (Fig. 177). This endoneurial fibrosis is more severe than has ever been seen after simple Wallerian degeneration. At some points the dense collagenous strands are separated by spaces containing aggregates of cells, some of which are similar to the



absence of any zone of active phagocytosis around the necrotic nerve is no doubt accounted for by the small size of the specimen, which included no living tissue in which such a reaction could arise.

The condition of the ulnar nerve in the upper part of the forearm is not known, but the histological changes in its dorsal cutaneous branch suggest that the damage was vascular in origin; two of the affected muscles (F.C.U. and F.D.P.) were supplied by branches arising above the level of the fracture, strong evidence in favour of a centripetal vascular change. The degenerative changes in the dorsal branch seem to represent a more advanced stage of the endoneurial collagenization seen in the interosseous branch of the median. Fibre degeneration has taken place, followed by gross endoneurial collagenization. The presence of numerous vessels indicates that an adequate circulation has been restored, but it was too late; fibre regeneration is impossible because Schwann cells have been destroyed and many of the Schwann tubes obliterated.

#### PROGRESS.—

Feb. 4, 1942: Median, no recovery.

Ulnar, no recovery.

Radial, recovery in proximal muscles (B.Rad., E.C.R.L., E.C.R.B., E.D.C., E.Min.D., E.C.U.) and one distal muscle, A.P.L.

Aug. 20, 1943: Median, none, apart from what could be ascribed to a little improvement in the unaffected proximal part of the common flexor group.

Ulnar, none.

Radial, distal muscles active except E.P.L. and E.I. Shrinkage of analgesia in the palm almost certainly due to overlap from neighbouring nerves.

**Case 2 (B.21).—**An airman born in 1910. Jan. 1, 1941: A land-mine exploded near the balloon site on which he was working. He sustained a head injury, simple fracture of five ribs on the left side with hæmopneumothorax, a few abrasions of the left forearm, and a closed fracture of the mid-shaft of the left humerus. Admitted to hospital; two days later the left arm was encased in plaster from the axilla to the wrist, with the elbow flexed to 90°. At no time did he complain of pain in the forearm and hand, but in the first few days he experienced tingling in the fingers. After two weeks the plaster was removed and the arm placed on a shoulder abduction splint. This splint caused a great deal of pain over the fractured ribs, and was abandoned in favour of the plaster. The arm was in plaster for eight and a half weeks and the fracture united normally. His radial pulse was absent during his nine weeks' stay in hospital. June 27: Admitted to the Wingfield-Morris Hospital. The fracture was firmly united in good alignment.

Aug. 27: Exploration of nerves, muscles, and vessels; arteriogram.

#### PRÉCIS OF FINDINGS.—

##### Vascular Damage.—

Pulse: In brachial artery normal in upper half of arm, very weak at elbow; radial pulse just palpable; ulnar pulse not palpable in either arm.

Oscillometry: Greatly reduced pulsations below mid-arm.

Skin Temperatures: No reflex vasodilatation in hand.

Arteriography: Injection above obstruction was made with some difficulty—none of it travelled distally. Injection below obstruction showed patency of radial and ulnar arteries, many anastomoses round the elbow, but otherwise few vessels outlined in forearm.

Direct Inspection: Normal artery as far down as site of humeral fracture; at this level encased in scar tissue and obviously obstructed; distally, diameter much reduced, pulsation very feeble.

#### Muscle Changes.—

	Voluntary Power	Faradic Response	Galtanic Response
B. Rad.	+	—	—
E.C.R.L.	flicker	—	—
E.D.C.	—	—	—
Other muscles in radial group	—	—	—
Upper end of P.T.	—	—	—
Other muscles in median group	—	—	—
Ulnar group	—	—	—

Perabrodil absorbed from common flexors on normal side in 25 minutes; on abnormal side, still present after two hours.

Appearances at Operation:

Except for upper 6 cm. of common flexor origin, common flexor group completely necrotic.

E.D.C. Reddish, fibrotic.

A.P.L. Patchy necrosis.

E.P.L. Necrotic.

E.I. Necrotic.

Histological Changes:

F.D.S. Necrosis

P.T. Dense fibrosis with areas of degenerating muscle between: indications of abortive regeneration.

E.D.C.

A.P.L.

**Nerve Damage.**—Complete sensory loss and anhidrosis of median and ulnar distribution: paralysis of intrinsic muscles of hand. Anaesthesia in superficial radial area (the patient believed that pain sensibility had returned during the three months preceding admission). At exploration at level of fracture median and ulnar nerves appeared normal and were not involved in scar tissue. Median nerve and its branches of normal consistency and diameter (6 mm.) as far as 6 cm. below medial epicondyle. Nerve passed between the deep and superficial heads of pronator teres, but, in contrast with Case 1, there was no sign of constriction. Below this level the nerve gradually narrowed, and in the lower forearm was only 3 mm. in diameter, avascular, atrophied, and fibrotic. No obvious constriction or neuroma at any level.

Faradic stimulation: weak response in upper 4 cm. of common flexor origin.

Ulnar nerve appeared normal (diam. 5 mm.) as far as epicondyle. Not exposed in upper half of forearm; in lower half diameter much reduced (2.5 mm.), same consistency as the median at this level. No response on stimulation.

#### HISTOLOGICAL EXAMINATION OF NERVES.—

a. Branch to P.T.—This branch contained numerous myelinated nerve-fibres, and while many of them



FIG. 179.—Case 2. Part of a nerve-bundle in the branch to pronator teres. Longitudinal section. Weigert-alum carmine. Scale = 40 $\mu$ .

were of large diameter, of the order of 12–14 $\mu$ , an equally large number were small, 3–6 $\mu$ . This represents an abnormally high proportion of small fibres and indicates that some of the normal (large) fibres have undergone degeneration and been replaced by others which have grown down from above, but had

not achieved their normal diameter. The large fibres present may either have escaped injury or have proceeded further in regeneration than the others. In longitudinal sections it can be seen that some of the nerve-bundles contain collections of myelin having the appearance seen in the early stages of Wallerian degeneration of large fibres (Fig. 179). This abnormality of the myelin sheath is probably greater than can be attributed to operative trauma and may indicate a persistent nutritional abnormality.

The connective tissue of the nerve contains an excess of small vessels, many of which are surrounded by considerable polymorphonuclear and lymphocytic aggregations. In one of the bundles there has been considerable hæmorrhage in the perineural connective tissue.

*b. Branch to F.D.S.*—This small branch contains only one nerve-bundle in which all the fibres have degenerated with no sign of regeneration. The condition of this nerve is similar to that of the dorsal cutaneous branch of the ulnar in Case 1. There are, however, a few cells present which may be Schwannian, though they are much less numerous than after normal Wallerian degeneration.

*c. Palmar Cutaneous Branch of the Median.*—This contains an abundance of myelinated fibres (Fig. 180), but as most of them are less than  $5\mu$  in total

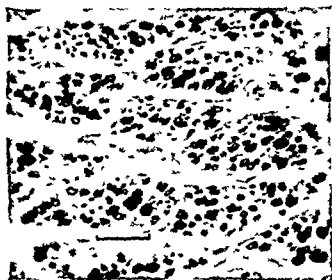


FIG. 180.—Case 2. Part of the palmar cutaneous branch of the median nerve. Transverse section. Weigert-alum carmine. Scale =  $40\mu$ .

diameter they are probably regenerating rather than normal undamaged fibres. The blood-vessels show a mild polymorphonuclear exudation and the endoneurial collagen fibres show a slightly abnormal thickening.

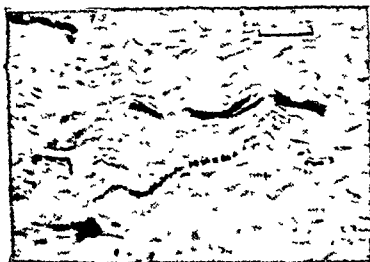


FIG. 181.—Case 2. A nerve-bundle from the dorsal cutaneous branch of the ulnar. Longitudinal section. Only two small myelinated nerve-fibres are visible. Weigert-alum carmine. Scale =  $40\mu$ .

*d. Dorsal Cutaneous Branch of the Ulnar.*—The fibres in this branch have all degenerated, and the few small myelinated fibres present (Fig. 181) presumably represent an incomplete and unsuccessful attempt at regeneration. Some of the Schwann tubes appear to

have retained their lumen, but others have been obliterated by thickening of the collagen fibres of the endoneurium (Fig. 182). The less severely damaged tubes contain Schwann cells, but the others are

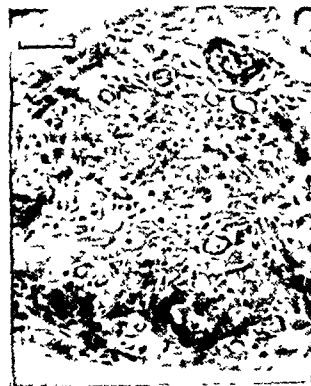


FIG. 182.—Case 2. The same nerve as in Fig. 181. Transverse section. Masson. Scale =  $40\mu$ .

occupied only by groups of mesodermal cells with an extensive foamy cytoplasm. A large artery accompanying the nerve is completely obliterated by an old thrombus, but within the endoneurium there is a large number of small normal vessels.

**SUMMARY.**—There is no doubt that in this case the nerve damage was ischaemic in origin.

The least severely affected nerve-branches were the branch to pronator teres, which arose high in the arm, and the palmar cutaneous branch which was the most distal specimen taken. But in both there is evidence of initial degeneration of some or all of the nerve-fibres, followed by regeneration. In the branch to flexor sublimis and in the dorsal cutaneous branch of the ulnar nerve-fibre degeneration was associated with destruction of many of the Schwann cells and gross collagenization of the endoneurium. Attempts at regeneration of myelinated fibres were absent or abortive. In all the nerves there was an abundance of small vessels containing apparently normal blood. The evidence indicates that the effect of the initial acute ischaemia is to cause nerve-fibre degeneration; and that in the areas in which this is most severe there is also Schwann-cell destruction and collagenization of the endoneurium. Later, when a collateral circulation has become established, regeneration of myelinated fibres takes place, but only in those nerves in which the Schwann cells are still alive and the Schwann tubes remain patent.

#### PROGRESS.

July 13, 1942: In the radial group several of the proximal muscles showed slight recovery, but there has been none in E.P.L., E.P.B., or E.I.

In the median and ulnar muscles there was only a flicker of contraction in F.C.U.

Sensory recovery is complete in the superficial radial area; there has been a slight recovery of pain sensibility in the palm in the ulnar area.

Oct. 26, 1943: Slight flicker in median group. Return of sweating and of touch and pain sensibility in radial area, with considerable overlap on to the median and ulnar areas. In median area shrinkage of zone of analgesia, but no recovery in ulnar area.

*Case 3 (M.32).*—A sailor born in 1900.

March 10, 1941: He was injured in a bomb explosion, and sustained multiple injuries including

wounds of the medial side of the right arm. He had immediate pain in the right elbow, but the hand and forearm felt normal until on trying to use the limb he found that he had no movement of the wrist or fingers, and that he had complete sensory loss in the hand. He was admitted to hospital where bomb

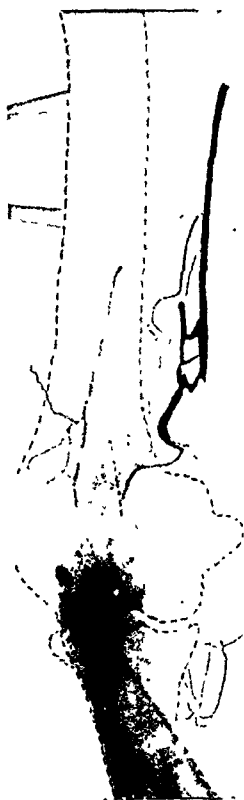


FIG. 183.—Case 3. Arteriogram. The brachial artery is obliterated at the level of the wound, and a large foreign body may be seen close by. Just above the site of obliteration there are several large anastomotic vessels. (The radiograph was unsatisfactory for reproduction, and the shadows of the vessels have been marked out with Indian ink).

splinters were removed, and the wounds were excised and (*nota bene*) sutured. The arm was immobilized in a Thomas splint.

March 12: It was noted that "the right arm was grossly swollen from the shoulder to the elbow. The wounds have been sutured under tension and are discharging serum". The sutures were removed and the wound packed with vaseline gauze. He had "total anaesthesia of the forearm and hand, with complete loss of motor power in the hand. The hand is warm and of good colour; there is no palpable radial pulse".

A radiograph revealed a comminuted fracture of the medial epicondyle of the right humerus.

March 13: All sutures removed, wounds insufflated with sulphanilamide powder, and a closed plaster applied.

April 21: There was "evidence of beginning flexor contracture of the fingers—slight resistance to complete extension".

Nov. 11: "Some evidence of return of function in the extensor muscles".

March 13, 1942: Admitted to the Wingfield-Morris Hospital.

March 25: Exploration of nerves, muscles, and vessels: arteriogram.

#### PRICIS OF FINDINGS.—

##### Vascular Damage.—

Pulse: Palpable in brachial artery down to mid-arm, very feeble at wrist.

Oscillometry: Poor pulsations in lower arm, barely perceptible in forearm.

Skin Temperatures: No reflex vasodilatation in hand.

Arteriography (Fig. 183): Complete obstruction in brachial artery 3 cm. above epicondyle.

Direct inspection confirmed this. Pulsation in radial artery visible in upper third of forearm.

##### Muscle Changes.—

	Voluntary Power	Faradic Response	Galtanic Response
E.P.L. } E.P.B. } E.I. }	flicker	—	—
Other extensor muscles	normal		
Common flexor origin, proximal few cm.	flicker	—	—
All other forearm muscles in median and ulnar groups	—	—	—
Intrinsic muscles of hand	—	—	—
Appearances at Operation:	Histological Changes:		
All forearm flexors necrotic.	P.T. Degeneration and interstitial fibrosis.		
E.P.L. } E.P.B. } necrotic E.I. }	F.D.S. Necrosis.		
	E.D.C. Necrosis.		
	E.P.L. Similar to P.T.		

Nerve Damage.—Complete sensory loss and anhidrosis of median, ulnar, and medial cutaneous (forearm) distribution. Paralysis of intrinsic muscles of hand. Diminution of sensibility and sweating in superficial radial area.

At exploration, medial cutaneous nerve of forearm completely divided 11 cm. above medial epicondyle.

Ulnar: 11 cm. above medial epicondyle a very large fusiform neuroma (Fig. 184), consistency quite

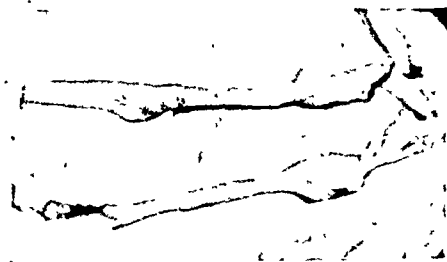


FIG. 184.—Case 3. The nerve lesion as exposed at operation. There are two lateral neuromata on the median nerve, and a large fusiform neuroma on the ulnar. The proximal neuroma on the medial cutaneous nerve of the forearm is also visible.

soft, and below it nerve was of normal diameter. Behind epicondyle nerve buried in scar tissue, but apparently normal except for slight epineurial fibrosis. Beyond a point 5 cm. below epicondyle it gradually became atrophied and fibrotic, in lower third of forearm diam. only 2 mm. Median: diam. 6 mm. proximally. At same level as ulnar and medial cutaneous lesions, there was a conspicuous lateral neuroma (Fig. 184); diam. below, 6 mm. There was a second lesion 8 cm. below the first, and at the same level as the arterial lesion; it was also a lateral neuroma, on the anterior surface of the nerve (Fig. 184). Below this level the nerve became involved in

scar tissue in the antecubital fossa, but after dissection it appeared normal (diam. 5 mm.). It continued so for 6 cm. below the epicondyle, beyond which it gradually shrank, was apparently avascular, and felt fibrotic. No obvious constriction between heads of P.T. In lower third of forearm diam. only 2.5 mm.

Electrical stimulation of both median and ulnar nerves negative.

#### HISTOLOGICAL EXAMINATION OF NERVES.—

*a. Branch to F.D.P.*—This nerve contains many myelinated fibres, but most of them have a total diameter of only 4–5 $\mu$ , or less, and there has been proliferation of the Schwann cells. Thus, it appears that an initial complete fibre degeneration has been followed by recent regeneration.

*b. Branch to P.T.*—The nerve-fibres in this specimen have degenerated completely: in addition there has been considerable thickening of the endoneurial collagen so that many of the Schwann tubes have been obliterated, and there are many fewer Schwann cells present than would be expected in a nerve which had undergone simple Wallerian degeneration. The branch is abundantly supplied with blood-vessels containing normal blood: these are found both within the bundles and in the epineurium. Numerous polymorphonuclear leucocytes can be seen emigrating from all the vessels, and they form collections in the epineurial connective tissue.

*c. Branch to F.D.S.*—Here again all the nerve-fibres have degenerated, and collagenization within the bundle has, in some areas, proceeded further than that in the branch to P.T. Thus, at some levels bundles can be seen in which the lumina of the Schwann tubes have not been obliterated, and Schwann cells are still present within them, the only abnormality being a slight thickening of the endoneurium; while at other levels the bundles consist entirely of dense strands of collagen showing no tubular structure, and in places this intraneurial collagen is acellular and shows hyalinization. In one transverse section a bundle was seen in which half of its area was occupied by Schwann tubes with a thickened endoneurium, while the other half contained only a dense mass of longitudinally orientated collagen.

*d. Dorsal Cutaneous Branch of Ulnar.*—The nerve-fibres are degenerate, but removal of the products of myelin sheath breakdown has not proceeded normally. At many points in the Weigert-Pal preparations granular masses of black-staining material can be seen occupying spaces similar in dimensions to normal nerve-fibres (Fig. 185). In normal Wallerian degeneration these breakdown products would have disappeared long ago. Trichrome preparations show that the normal structure of the nerve has largely disappeared as a result of the formation of dense intraneurial collagen masses. This collagen shows patchy hyaline change with loss of affinity for collagen stains. The few cells present in the nerve have the appearance of phagocytes (Fig. 186) and many of them show nuclear degenerative changes. The perineurial and epineurial connective tissues of the nerve are similarly composed of acellular degenerating collagen. The nerve contains only a very small number of minute blood-vessels.

**SUMMARY.**—In view of the evidence of partial traumatic interruption of the median and ulnar nerves, some Wallerian degeneration was to be expected in all the branches excised for histological examination. It is, however, evident that there has been a considerable degree of regeneration through the median lesion at least, since the branch to F.D.P. was extensively re-innervated. But all the other branches are

not only devoid of fibres, but show changes that are not typical of normal post-traumatic Wallerian degeneration, and these must be attributed to the ischaemia accompanying the direct injury of the main nerve-trunks. In specimens (b), (c), and (d) various grades



FIG. 185.—Case 3. A nerve-bundle from the dorsal cutaneous branch of the ulnar in a transverse section at a proximal level. Myelin remains still occupy the old nerve-fibre tubes, and the endoneurium is thickened. Weigert-alum carmine. Scale = 40 $\mu$ .

of endoneurial collagenization are seen, and in specimen (d), in which there is no evidence of establishment of collateral circulation, the collagen which has occupied

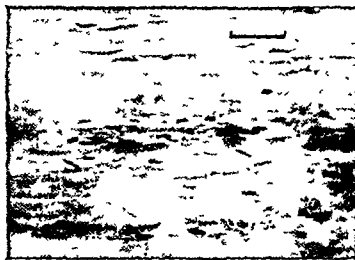


FIG. 186.—Case 3. The same nerve as that in Fig. 015, shown in longitudinal section at a distal level. Masson.

the nerve shows signs of degenerative change. Furthermore, in specimen (d) there has been a failure of the normal process of phagocytic removal of myelin breakdown products, indicating a persistent abnormality in the nutrition of this branch.

#### PROGRESS.—

June 26, 1942: No evidence of recovery in median or ulnar nerve: slight evidence of improvement in the radial distribution, except in E.P.L., E.P.B., and E.I. The patient has not been available for re-examination since this date.

*Case 4 (G.24).*—A civilian motor engineer born in 1880.

Nov. 2, 1940: Caught his left arm in the carrier of a lathe and sustained a fracture of the surgical neck of the humerus, fracture of the mid-third of the radius and ulna, soft-tissue injuries of the arm and axilla, and a complete brachial plexus paralysis. Admitted to hospital; axillary wound excised and sutured, both fractures reduced and immobilized by shoulder spica.

Dec. 15: Plaster spica was removed and arm placed in a sling. "Sensation from shoulder to elbow now present. Less swelling of the hand and the skin seems more vital".

Jan. 15, 1941: "Indefinite sensation to mid-forearm, definite contraction in deltoid, biceps, and triceps".

March 10: "Sensation to pin-prick 2-3 finger-breadths above the ulnar styloid".

July: "Some movement began to return to the fingers".

April 24, 1942: Admitted to the Wingfield-Morris Hospital. At no time had he complained of pain in the hand.

May 13: Exploration of nerves and muscles; arteriogram.

#### PRINCIPAL FINDINGS.—

##### Vascular Damage.—

Pulse: Feeble in axilla, impalpable at wrist.

Oscillometry: Slight pulsation only in upper third of arm.

Arteriography (third part of subclavian): Complete obstruction at level of fracture of neck of humerus.

##### Muscle Damage.—

	Voluntary Power	Faradic Response	Galvanic Response
B. Rad.	+	+	+
E.C.R.L.	+	+	+
E.D.C.	+	+	+
Other extensor muscles	+	+	+
P.T.	+	+	+
F.C.R.	+	+	+
P.L.	+	+	+
F.D.S.	+	+	+
Other muscles in median group	+	+	+
F.C.U.	+	+	+
F.D.P.	+	+	+
Ulnar intrinsic	+	+	+
Appearances at Operation:	Histological Changes:		
E.D.C. Fibrotic	} Necrotic	A.P.L. Necrosis and fibrosis.	
A.P.L.		E.I. Necrosis.	
E.P.L.		Normal and degenerate fibres	
E.P.B.		Necrosis.	
E.I.		Degeneration.	
Superficial forearm muscles: apparently normal.			
Deep muscles: necrotic.			
First dorsal interosseous: pale red and atrophic: no electrical response.			

**Nerve Damage.**—Diminished sensibility and hypohidrosis in median, ulnar, and superficial radial areas: paralysis of intrinsic muscles of hand. At exploration (forearm only), median nerve atrophied (diam.



FIG. 187.—Case 4. Transverse section of a nerve-bundle at a proximal level in the dorsal cutaneous branch of the ulnar. Masson. Scale = 40 $\mu$ .

3 mm.) fibrotic, very firm, and avascular. Faradic stimulation, weak response in A.P.B. Ulnar similar, diam. 2 mm.; no response on stimulation.

#### HISTOLOGICAL EXAMINATION OF NERVES.—

**a. Dorsal Cutaneous Branch of Ulnar.**—Examined in transverse and longitudinal section throughout its length. There is no significant difference in the condition of the nerve at the proximal and distal levels. The bundles have all suffered considerable

endoneurial collagenization (Fig. 187), though the severity of the change varies at different points within the bundles. Thus, in some areas the Schwann tubes have an unobstructed lumen and contain regenerating nerve-fibres with myelin sheaths. But at other points the nervous tissue has been completely replaced by collagen (Fig. 187), and this shows a degenerative change manifested by absence of nuclei and patchy abnormality of staining reactions: thus, it takes up the plasma stain in Masson's method, and the picric acid rather than the acid fuchsin in haematoxylin—van Gieson preparations. The numerous blood-vessels contain apparently normal blood, and there is only a very mild inflammatory reaction.

**b. Branch of the Superficial Radial Nerve.**—This branch contains some myelinated nerve-fibres: the Schwann cells have proliferated, but there is no significant degree of endoneurial collagenization, and the nerve thus has the appearance of being in the process of re-innervation after degeneration of a typical Wallerian kind.

**SUMMARY.**—Transient brachial plexus paralysis (neurapraxia). Ischemic lesions of deep flexor group in forearm, distal extensors, and of median and ulnar nerves.

The varying severity of the collagenization at different points in the dorsal cutaneous branch demonstrates the continuity of the different grades of collagenization that have been found in all these cases. The presence of regenerating and myelinated fibres in those Schwann tubes that have retained their individuality indicates that regeneration of nerve-fibres is possible if collagenization has not gone too far, and if a good circulation has been re-established. But it seems unlikely that normal motor-fibres of maximal diameter could ever be formed even in these intact Schwann tubes, since the endoneurial tissue between them is considerably thickened and would surely prove a persistent hindrance to the increase in fibre diameter which is a necessary part of the process of regeneration.

#### PROGRESS.—

June 26, 1942: No improvement, except for a flicker in A.P.B.

Sept. 18, 1943: Slight increase in power of active muscles; flicker in F.P.L., otherwise no change.

Pain sensibility has returned in the distribution of the dorsal branch of the ulnar. Anaesthesia in the median and ulnar areas has diminished in extent.

**Case 5 (S.35).**—A civilian radio-electrician born in 1905.

Jan. 7, 1942: Sustained a left Colles's fracture while boxing. On his way to hospital he felt some pain in the hand, but cannot remember if there was any disturbance of sensibility. Fracture manipulated under anaesthesia, perfect reduction obtained, and a complete skin-tight plaster applied. Later, he could move his fingers but could not "feel them properly". During the night severe pain in the forearm muscles, increased by movement of the fingers.

Jan. 8: Reported at hospital; fingers were swollen but could be moved voluntarily; sensibility was not tested.

Jan. 10: A little plaster removed from the palm, slightly easing the pain. The patient could still move his fingers, but sensibility was probably diminished.

Jan. 11: Plaster split.

Jan. 12: Plaster removed; skin severely blistered on front of forearm; blisters removed under anaesthesia, fracture re-manipulated and complete skin-tight plaster applied.

Jan. 14-March 27: Further treatment. During this period it became clear that there was a serious loss of motor and sensory function in the hand.

March 30: Admitted to Wingfield-Morris Hospital.

May 6: Exploration of nerves, muscles, and vessels; arteriogram.

Appearances at Operation:  
F.D.S. } Necrotic  
F.D.P. } distally

E.P.L. } No necrosis:  
E.I. } responded to  
faradism.  
First dorsal No necrosis  
interosseous.

Histological Changes:  
F.D.S. Necrosis.  
E.P.L. Fibrosis and a patch  
of necrosis.

Hyalinization and fibrosis.

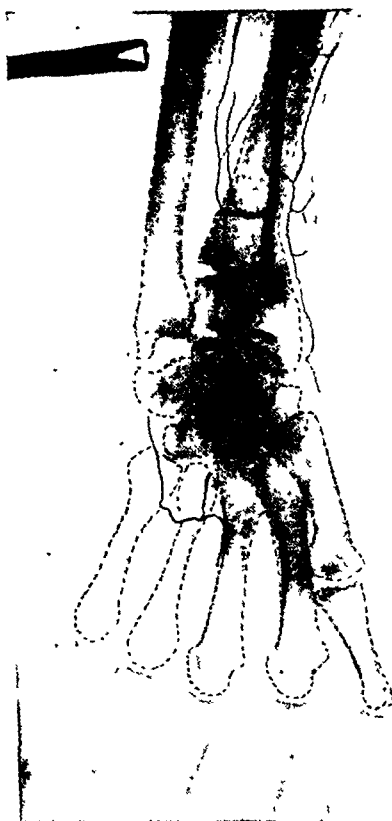


FIG. 188.—Case 5. Arteriogram after injection into the radial artery below the middle of the forearm. This artery is obstructed at the level of the radial fracture, and several anastomotic vessels arise above the site of obstruction. The vascular arch in the palm is outlined only over the base of the 4th and 5th metacarpals. This arteriogram was repeated with the same result.



FIG. 189.—Case 5. Arteriogram obtained by injection of the ulnar artery below the middle of the forearm. There is no obstruction of the ulnar artery and the deep arch in the palm is well outlined. (In this and Fig. 188 the shadows of the vessels have been blackened with Indian ink.)

#### Vascular Damage.—

Pulse: Normal in radial artery at wrist. Hand pinker but colder than normal.

Oscillometry: Pulsations greatly reduced in lower half of forearm.

Arteriography: Obstruction in radial artery at level of fracture, many anastomoses proximal to it, but superficial palmar arch not filled (Fig. 188). Ulnar artery patent and deep arch well filled (Fig. 189).

Direct inspection confirmed obstruction in radial artery.

#### Muscle Damage.—

	Voluntary Power	Faradic Response	Galvanic Response
A.P.L.	—	weak +	—
E.P.L.	—	—	—
E.P.B.	—	—	—
Other extensor muscles active	—	—	—
F.P.L.	—	—	—
Thenar muscles	—	—	+
Other muscles in median group active	—	—	—
Ulnar intrinsics	—	—	—
Other muscles in ulnar group active	—	—	—

**Nerve Damage.**—Complete sensory loss and anhidrosis in distribution of median, ulnar, and superficial radial nerves (Fig. 190): paralysis of intrinsic muscles of hand.

At exploration, median nerve normal, diam. 6 mm. down to 16 cm. above the wrist, then progressive shrinkage, diam. 2.5 mm. at 13 cm. above wrist: firm, fibrotic, but not avascular. No neuroma. In carpal tunnel, apparently normal again; thus, shrinkage extended over 13 cm.

Ulnar: At 12 cm. above wrist began to shrink, quickly reaching diam. 2 mm., firm and fibrotic, but vascularity doubtful. No response on stimulation of either nerve.

#### HISTOLOGICAL EXAMINATION OF NERVES.—

a. *Dorsal Cutaneous Branch of the Ulnar.*—After fixation the specimen was 13 cm. in length: it was examined at different levels.

The most proximal 4 cm. of the nerve show no great abnormality of the connective tissue: in the bundles, however, although normal large myelinated fibres are present at the periphery, the fibres in the middle have undergone degeneration. But in this

area there has been abundant regeneration from above, and the Schwann tubes, with their proliferated Schwann cells, contain many fine thinly myelinated axons. There is slight endoneurial œdema, but no other remarkable change.



FIG. 190.—Case 5. Complete sensory loss and anhidrosis in the median and ulnar areas, and in the distribution of the superficial radial nerve. The area of sweating and sensibility over the dorsum of the 1st interosseous space is almost certainly innervated by the lateral cutaneous nerve of the forearm.

In the next 3.5 cm. of the nerve the number of myelinated nerve-fibres present gradually decreases, though there are still many small fibres in the process of regeneration: myelin remains show all stages of removal by phagocytes. There is a mild polymorphonuclear and lymphocytic infiltration of the tissues

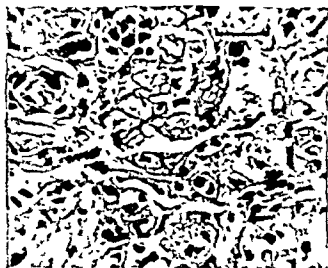


FIG. 191.—Case 5. Part of a nerve-bundle in the dorsal cutaneous branch of the ulnar at a point at which there is no great fibrosis of the endoneurium between the Schwann tubes. Masson. Scale = 20 $\mu$ .

conspicuous abnormality. The endoneurium is, perhaps, slightly thickened.

#### PROGRESS.—

Aug. 26, 1943: Of the paralysed median muscles F.P.L. alone has recovered; feeble contraction in the ulnar intrinsics. Sweating and sensibility have returned in the radial area, and in the palmar area of the ulnar. Slight shrinkage in the area of median analgesia, probably due to overlap.

Case 6 (G.58).—A soldier born in 1917.

Nov. 19, 1943: Motor-cycle crash; closed fracture of upper third of right radius and ulna, open fracture right tibia and fibula. Admitted to hospital without delay: forearm fracture reduced, and plaster applied from mid-arm to palm, with elbow flexed 90°; appropriate treatment for lower-limb injury.

Nov. 20: Arm painful, fingers swollen and blue; plaster bivalved, which relieved the pain. On the following day the fingers were flexed and could not be extended without causing pain. Median and ulnar paralysis first noticed.

March 30, 1944: Admitted to Wingfield-Morris Hospital.

May 17: Exploration of nerves and muscles; arteriogram.

#### PRICIS OF FINDINGS.—

Vascular Damage.—

Pulse: Normal.

Oscillometry: No significant departure from normal.

Arteriography: Slight narrowing in upper part of radial artery, absence of branches in main muscle mass of forearm and no filling of distal quarter of anterior interosseous artery. No sign of this vessel at operation.



FIG. 192.—Case 5. The same nerve as that in Fig. 191, but at a point at which there is considerable thickening of the endoneurial collagen. Transverse section. Masson. Scale = 20 $\mu$ .

around the blood-vessels. In the distal 6 cm. of the nerve there are no normal nerve-fibres present, all are in the process of regeneration, and they seem to be less numerous than at the more proximal levels. Some of the nerve-bundles show an unmistakable excess of collagenization of the endoneurium; this can be very clearly demonstrated by comparing the different bundles in the same transverse section of the nerve (Figs. 191, 192). But at no level has the collagenization proceeded to complete obliteration of the lumina of the Schwann tubes. Throughout this distal segment of the nerve there is patchy infiltration of the bundles with dense masses of inflammatory cells, and the whole nerve appears to be hypervascularized.

b. *Palmar Cutaneous Branch of the Median.*—This very small nerve has undergone complete Wallerian degeneration, but shows no necrosis or other

#### Muscle Damage.—

Muscle Damage.	Voluntary Power	Faradic Response	Galvanic Response
P.T.	+	+	
F.C.R.	+	+	
P.L.	+	+	
F.D.S.	+	+	
F.P.L.	+	?	?
F.D.P.	—		
P.Q.	?	not examined	
A.P.B.	—		+
O.P.	—		+
F.P.B.	—		+
+, grade 2			
Ulnar muscles: All acting, but weak.			
Radial muscles: distal muscles, except E.I. and (?) E.P.B., weak but active: proximal muscles strong.			
Appearances at Operation:			
Necrosis of lower half of F.D.P. and whole of P.Q.		Histological Changes:	
A.P.B. Typical degenerate muscle.		Confirmed macroscopical findings.	

**Nerve Damage.**—Incomplete anhidrosis and partial loss of sensibility in the median and ulnar areas. Paralysis of median and paresis of ulnar intrinsic muscles of the hand (F.P.B. supplied by ulnar nerve).

At operation only the median nerve was explored. At 16 cm. below the medial epicondyle the diameter of the nerve shrank from 6 by 4 mm. to 4 by 4 mm.; appearance of bundles lost, sheath fibrotic, consistency apparently normal, nerve purplish and obviously well vascularized. At 23 cm. below the epicondyle the diameter returned to normal and the appearance became that of ordinary Wallerian degeneration. Faradic stimulation: no response in F.D.P., P.Q., O.P., or F.P.B.; F.P.L. and A.P.B. raised threshold. One small bundle removed from narrowed portion of nerve-trunk.

**HISTOLOGICAL EXAMINATION OF NERVE.**—The specimen was 3 cm. in length after fixation: it was examined in transverse section at five levels.

At its proximal end the specimen contained four small nerve-bundles; at the distal end only one bundle was included, but the condition of the nerve was similar at all levels. In most respects the appearances were those of a nerve which had undergone simple Wallerian degeneration followed by a re-innervation by regenerating axons from a proximal level: thus, no normal-sized nerve-fibres were present, the Schwann cells were proliferated, and the

The macroscopical and microscopical evidence indicates that the nerve had undergone axonotmesis complicated by a moderately excessive endoneurial thickening. Re-innervation by regenerating axons was well advanced, and spontaneous recovery could be expected since the nerve had not been completely interrupted at any point. The quality of recovery might, however, be impaired by the abnormal condition of the endoneurium around the regenerating fibres.

**PROGRESS.**—By June 20, 1944, there was great improvement in the power of the intrinsic muscles of the hand, and sensibility, including two-point discrimination, was almost perfect. Thus, this case provides clear evidence of the degree of ischaemic damage that is compatible with good recovery.

## DISCUSSION

### Signs of Impairment of the Circulation.—

1. **Pulse.**—In Case 1, in which the radial artery was injured in the mid-forearm, the radial pulse was absent immediately after the injury, but returned slightly after manipulation of the fractures of the radius and ulna. It was certainly present when the patient was referred to us 15 days later, but was only half as forcible as on the normal side.

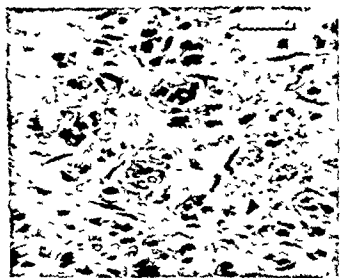


FIG. 193.—Case 6. A transverse section of part of one bundle from the median nerve. Masson. The Schwann tubes lie in groups separated by increased endoneurial collagen. In many of the tubes the myelin sheaths of the small nerve-fibres which they contain can be distinguished as dark rings. Scale = 20 $\mu$ .

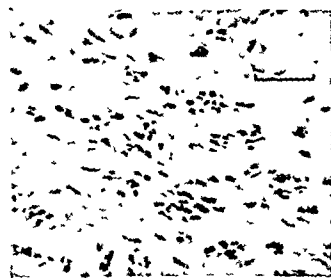


FIG. 194.—Case 6. The same area as that shown in Fig. 193 in an adjacent section stained with buffered silver nitrate to demonstrate nerve-axons. All the Schwann tubes are abundantly re-innervated. Scale = 20 $\mu$ .

Schwann tubes all contained fine regenerating nerve axons (Figs. 193, 194). But the endoneurial connective tissue was thickened to an extent greater than that characteristic of Wallerian degeneration. This thickening varied in degree at different levels, and at different points in the sections; but it had nowhere proceeded to complete obliteration of the lumina of the Schwann tubes.

**SUMMARY.**—The pre-operative diagnosis of ischaemic muscle and nerve damage was based on the intractability of the flexor contracture, and the presence of nerve lesions which could not be attributed directly to the fracture. The arterial spasm was probably widespread at first, but passed off fairly quickly, since there was considerable recovery in most of the forearm muscles during the two months preceding operation. However, it appears that the distal part of the deep circulation of the forearm had been gravely disturbed, and the anterior interosseous artery had disappeared completely in its peripheral part. Here there was gross muscle necrosis and moderate ischaemic damage of the median nerve, and perhaps of the ulnar.

In Case 2 the brachial artery was injured in the mid-arm. The radial pulse was absent for at least a week after the injury, and six months later both brachial and radial pulses were extremely weak below the site of injury.

In Case 3 the brachial artery was injured just above the elbow. The radial pulse was absent for at least 2 days, and was extremely weak 12 months later.

In Case 4 the axillary artery was damaged; the brachial pulse was scarcely palpable when the patient was referred to us almost six months later, and only when the limb was warm was there even a flicker of a radial pulse.

In Case 5, in which the radial artery was injured, the radial pulse was normal three months after injury, but the arteriogram showed that the site of the arterial injury was at the wrist, below the level at which the pulse was palpable.

In Case 6 there was no detectable abnormality.

2. **Oscillometry.**—In all cases the oscillometer recordings demonstrated a serious impairment of



circulation below the level of arterial injury: there was also slight reduction of oscillations immediately proximal to it. Thus in *Case 1* there was diminution in the recordings in the upper third of the forearm (see *Fig. 171*), though the damage to the radial artery was a little below this level. And in *Case 5* oscillations were considerably reduced in the lower half of the forearm, though the arterial injury was at the level of the wrist.

3. *Skin Temperatures*.—Our series of cases suggests that little value can be attached to recordings of skin temperature in the late diagnosis of ischaemic contracture. It is well known (Richards, 1943) that after division of a peripheral nerve the skin temperature in the denervated zone is at first raised, owing to paralysis of the sympathetic vasomotor nerves, and reflex vasodilatation is no longer possible. After an interval, usually about 21 days, it begins to fall, and eventually the temperature of the denervated skin is considerably lower than that of the corresponding normal area at room temperature. If, as in all our cases, a serious vascular lesion is accompanied by a peripheral nerve lesion, the denervation of blood-vessels is alone sufficient to abolish reflex vasodilatation in the denervated cutaneous zone.

Thus, recordings of skin temperature made several weeks after uncomplicated nerve division are essentially the same as those obtained in limbs in which ischaemic damage is combined with a nerve lesion. But if recordings of skin temperature were to be made immediately after the injury, when vascular damage was first suspected, it would be found that in ischaemic limbs the digits would show no vasodilatation, while after simple nerve division this condition would not be observed until some weeks after injury.

4. *Arteriograms*.—In *Cases 1-5* arteriography showed that the main artery was obliterated at the level of the injury; in *Case 6* there was a suggestion of obliteration of the anterior interosseous artery; and in all except *Case 2*, where the arteriogram attempted by injection above the level of injury was unsuccessful, there were signs of establishment of a collateral circulation. Many fine blood-vessels could be seen extending from the artery above the site of obstruction to the arterial branches below the obstruction, and in all cases some blood-vessels were outlined distally in the limb: this collateral circulation was adequate to prevent gangrene. In the cases in which the radiograph included the area of muscular necrosis there was evidence of poor local circulation, as there was a striking deficiency of fine blood-vessels passing into the necrotic muscles (*Figs. 172, 183*).

Our short series of cases reinforces the view of Griffiths (1940), Horwitz (1942), Foisie (1942), and others that Volkmann's paralysis is produced by damage to a main artery, and that the resulting vascular spasm may extend proximal to the site of damage and, as in *Case 5*, to comparatively remote vessels.

### The Condition of the Muscles.—

1. *Electrical Testing*.—In assessing motor paralysis in cases of this kind it is important to distinguish between muscles whose inactivity is due to simple denervation and those which have also undergone necrosis or other changes distinct from simple denervation atrophy. This ought not to be difficult, since necrotic muscle fails to respond to any form of mechanical or electrical stimulation, while denervated muscle should show the reaction of denervation—a loss of faradic excitability and a slow response to galvanic stimulation. But there are two difficulties in the examination of ischaemic limbs which detract from the diagnostic value of percutaneous electrical stimulation. Firstly, the circulation of the limb is impaired, and there is often considerable oedema of the subcutaneous tissues: under these conditions percutaneous stimulation is unreliable, for even muscle which is relatively unharmed by ischaemia may fail to respond. Thus in *Cases 1* and *2* most of the extensor muscles in the forearm showed no response to percutaneous faradic or galvanic stimulation, but at exploration necrosis was found to be confined to the three most distal muscles; the proximal muscles, which failed to respond to any form of percutaneous stimulation, have since recovered voluntary power. Secondly, the necrosis of a muscle is often incomplete or patchy, and in this case the response to stimulation by the non-necrotic parts may suggest that the whole muscle is unaffected by ischaemia. This is where electromyography should prove a useful diagnostic aid.

### The Nerve Lesions.—

1. *The Aetiology of the Nerve Lesions*.—Three possible explanations of the extensive sensory and motor paralysis accompanying the muscular contracture require consideration.

a. *Direct traumatic nerve injury*: In three of our cases there was a suggestion that the sensory and motor paralysis might have been due to direct injury to nerves at the time of the original accident; and of these, *Case 4* showed a rapid recovery from the traumatic brachial plexus lesion (neurapraxia) in all parts of the limb proximal to the ischaemic zone. In four of the cases careful examination of the nerves at the site of injury failed to show any sign of complete or partial traumatic division. The only peripheral nerve lesions which may exist without local macroscopical evidence of abnormality are neurapraxia and axonotmesis (Seddon, 1944), and such lesions would have recovered rapidly and spontaneously.

b. *Nerve injury secondary to contracture of the muscles or compression by scar*: The view that the nerve lesions of ischaemic contracture are due to compression was put forward by Thomas (1909). More recently it has been supported by Meyerding (1930), who writes: "Nerves are commonly involved as a result of direct trauma at the time of the accident, and may be completely severed;

later callous compression, contracture from scar, intrinsic pressure from hæmatoma, inflammation, or exterior pressure due to flexion, splints, or bandaging may result in degeneration and paralysis. Contracture from scar and pressure . . . no doubt account for the majority of cases of paralysis of nerves."

This view requires for its substantiation both the operative demonstration of compression of the nerves and evidence that relief of the compression results in a substantial recovery. It implies, also, that the changes in the nerve distal to the lesion are of the simple Wallerian type, and from this it would follow that regeneration should occur if downgrowing axons can make their way unhindered peripherally. At operation, one would expect to find a fusiform neuromatous swelling above the constriction; and, below, the nerve would be no smaller than after Wallerian degeneration (Guttmann and Medawar, 1942).

In only one of our cases (*Case 1*) was there any evidence of compression: here the median nerve was constricted between the heads of origin of pronator teres. But there was no swelling above and there was extreme shrinkage of the nerve below. In the other cases the great shrinkage in diameter of the main nerve-trunk first became visible at a level at which there was no sign of external compression, and it is therefore not unreasonable to suggest that the compression in *Case 1* was coincidental. Lastly, a nerve lesion due to compression by contracting muscle or proliferating scar tissue would be of gradual onset, while in all our cases the signs of nerve interruption were evident immediately after the injury.

Thomas's review of the cases in the literature included some in which the nerves were carefully freed throughout their length, and others in which neurolysis was not performed. He pointed out that all the cases in which the nerve was freed showed some neurological improvement, but he offered no evidence that the quality of this recovery was any better than that of the spontaneous recovery which occurred to some extent in many of the cases, whether neurolysis was performed or not.

*c. Nerve injury caused by ischæmia of the nerve itself:* From our short series of cases we have concluded that local ischæmia of the nerve is the cause of the nervous paralysis accompanying ischæmic contracture. The remarkable atrophy and induration of the main trunks in the ischæmic zone was quite unlike any condition seen after uncomplicated nerve division; and the histological picture is unlike that of Wallerian degeneration—substantial evidence of a non-traumatic origin of the lesions.

If any further proof were required, it is supplied by *Case 5*. It is conceivable that a zone of ischæmia might not extend to the most distal part of a limb; in such a case only that part of the nerve traversing the ischæmic zone would be affected by ischæmia, and in the most distal part

the changes should be simply those of Wallerian degeneration, with no more shrinkage in diameter than goes with it. In *Case 5* the ischæmia was asymmetrical, the radial artery being chiefly affected: the ulnar and the deep palmar arch were patent. The median and ulnar nerves in the lower forearm were extremely shrunken and fibrotic, but at the wrist the median nerve (the ulnar was not followed into the palm) resumed its normal proportions and, what is even more significant, the palmar cutaneous branch of the median showed only *Wallerian degeneration*. Thus it is possible to have a zone of ischæmic degeneration of limited extent, with simple Wallerian degeneration beyond it.

*2. The Pathology of the Nerve Lesions.*—Peripheral nervous disorders have been described in association with vascular lesions, and often attributed to them. Adams (1942) has reviewed the literature on 'ischæmic neuropathies', and points out that in many cases this hypothesis was accepted without adequate evidence. His own experimental work shows that nerve-trunks can withstand a remarkable degree of interference with their regional blood-supply without showing histological evidence of abnormality (Adams, 1943). On the other hand, there have been numerous convincing demonstrations that abnormalities of the vasa nervorum are found in association with lesions of nerves occurring in vascular disorders of the extremities. Amongst these may be mentioned the work of Lapinsky (1898 and 1899); Priestley (1932), and Marcus (1933) on arteriosclerosis; Woltman and Wilder (1929) on diabetes mellitus; Barker (1938) on thrombo-angiitis obliterans; and Pančenko (1941) on 'spontaneous gangrene'.

Our specimens of ischæmic nerve showed considerable variation in the severity of the pathological change. In the least abnormal specimens there had been axon and myelin degeneration entirely similar to the Wallerian degeneration following simple nerve interruption. At the other extreme (branch to F.D.S. in *Case 1*), there is complete destruction of all cells in the nerve, just as in the most severely affected ischæmic muscles; and there is no doubt that this 'nerve infarction' is widely distributed in and near the necrotic muscle.

We found no evidence in our material of segmental demyelination, such as is said to be found in some forms of neuritis; but this is hardly surprising, since Doinikow (1913), after studying degeneration and regeneration in nerves subjected to toxic agents, pointed out that local demyelination is only maintained if the toxic agent is persistently active. In our cases it may be assumed that there was an initial period of acute ischæmia at the time of the injury. In the regions in which this ischæmia was not sufficient to cause necrosis or obliteration of the nerve by fibrosis, the nerve lesion may have involved either destruction of the axons and myelin of the fibres, or only local demyelination. In the

period subsequent to the injury the local ischaemia becomes less severe through the gradual improvement of the collateral circulation: even in nerves which had been severely affected by ischaemia there were often numerous small blood-vessels. When this collateral circulation is established, or when spasm of arterioles passes off, injury localized to the myelin sheath will be repaired, and completely degenerate fibres will be replaced by axons regenerating from above. In this way it is possible to explain the absence of evidence of local demyelination, and the frequent presence of regenerating fibres in nerves which had previously undergone degeneration of the Wallerian type.

The ischaemic change which is of the greatest interest and significance is that of endoneurial collagenization. Fibre regeneration is possible if the nerve has undergone only Wallerian degeneration; and functional recovery can be expected if an adequate local circulation is restored, and if the end-organs are not permanently damaged. But gross endoneurial collagenization, like necrosis, is an irreversible change. Our specimens have shown this process of thickening of the collagen between the nerve-fibre tubes (Schwann tubes) of every degree between a slight increase in the thickness of the collagen fibres and complete replacement of all structures within the nerve-bundle by a dense mass of collagen, sometimes itself showing degenerative changes.

Regeneration after Wallerian degeneration requires the downgrowth of new axons through the Schwann tubes left after absorption of the axons and myelin of the original fibres. If ischaemic degeneration leads not only to fibre degeneration but also to obliteration of the Schwann tubes by collagen, then no regeneration is possible. And even if the process continues only as far as an increase in endoneurial collagen without obliteration of the lumina of the tubes, it is likely to produce a serious and probably permanent hindrance to satisfactory functional recovery. It has been shown that for many months after Wallerian degeneration there is a progressive shrinkage in the diameter of the lumina of the Schwann tubes in the distal stump (Holmes and Young, 1942), and that the longer this shrinkage is allowed to continue, the more imperfect is the quality of functional recovery that follows secondary suture and re-innervation of the distal stump. Sanders and Young (1944) have produced experimental evidence that the diameter of the lumen of the Schwann tube into which a regenerating axon grows has a powerful influence in determining the final diameter that the fibre can achieve in regeneration. And as satisfactory functional recovery requires the presence of many myelinated nerve-fibres having a diameter much larger than that of the Schwann tubes before re-innervation, any factor tending to prevent this 'swelling' of the tube is certain to hinder recovery of function.

It therefore seems highly probably that the grade of endoneurial collagenization seen in many examples of ischaemic nerve will offer a permanent bar to full recovery of function in the new fibres. The poor quality of recovery in all but one of our cases bears out this conclusion.

References to endoneurial collagenization in ischaemic nerve are to be found in several reports in the literature, though they are seldom well documented. Lapinsky (1898) quotes earlier workers who described 'sclerosis of the nerve': in his own cases he noted considerable thickening in the endoneurial collagen, the degree of thickening being correlated with the degree of abnormality of the vasa nervorum. As in our cases the epineurium and perineurium were much less seriously affected. He suggested that fibre degeneration might often be secondary to this collagenization rather than directly due to ischaemia. Marcus (1933) noted endoneurial proliferation in arteriosclerotic nerves, and commented on the abnormally large number of small blood-vessels present in them: this hyper-vascularization was notable in most of our specimens. Finally, Pančenko (1941) speaks of 'intensive proliferation' of fibroblasts in the endo- and perineurium of nerves above the line of demarcation in amputated gangrenous extremities. No evidence of a significant degree of endoneurial collagenization is given in the other papers on ischaemic neuropathies mentioned at the beginning of this section.

3. *Recovery from the Nerve Lesions.*—In all our cases there has been recovery in the radial muscles of the dorsum of the forearm, except in the distal muscles which were necrotic, and sensory and sudomotor recovery has taken place in the distribution of the superficial radial nerve.

Except in *Case 6*, where sensibility returned almost to normal, there has been little evidence of recovery in the median and ulnar nerves: none was noted in *Cases 1* and *3*. In *Case 2* there was some recovery of pain sensibility in the proximal part of the median and ulnar areas: similarly there has been some sensory recovery in *Cases 4* and *5*, but in all of them it has been of a very poor quality. Only in *Cases 4-6* has there been any motor recovery in the intrinsic muscles of the hand; in *Cases 4* and *5* this was never more than a flicker of contraction of little value to the patient.

Thus it may be concluded that in severe cases of ischaemic contracture there is not only a failure of recovery in the necrotic muscles, but likewise in muscles which are not necrotic but are supplied by nerves damaged by ischaemia, and also that sensory recovery may be very imperfect. This failure of recovery is due to irreversible ischaemic change in the nerves. There is no evidence from our cases that any form of treatment has any significant effect on the recovery of nerve function, and we can only conclude with Griffiths that the aim in dealing with Volkmann's contracture must be to prevent it.

## SUMMARY

1. Six cases of established Volkmann's contracture were investigated, and in five of them damage to the main artery of the limb was demonstrated at the level of the initial injury.

2. In all cases there was extensive motor and sensory paralysis, but in only two of them was there evidence of direct traumatic injury to a main nerve-trunk.

3. In one of the cases the median nerve was constricted between the two heads of pronator teres, but in no other was there any evidence of compression of nerves by contracture of muscle or involvement in scar tissue. In the case mentioned the part played by compression was probably insignificant.

4. Histological examination of various small branches of the damaged nerves demonstrated a variety of pathological changes. The least severe was destruction of axons and myelin sheaths, as in uncomplicated Wallerian degeneration. In the more severely affected nerves there had been a great increase in the collagen of the endoneurium, sometimes leading to complete collagenous replacement of the nerve-bundle. And in one case the nerve was entirely necrotic, having undergone a change similar to that found in completely ischæmic muscle.

5. These changes are due to ischæmia of varying severity.

6. Sensory and motor recovery has been of poor quality in all but one case, and this is considered to be due to the irreversible nature of severe ischæmic nerve degeneration. The

exceptional case provides direct evidence of the degree of damage compatible with good recovery.

7. There is no effective treatment for established ischæmic nerve degeneration. If the ischæmia has been so transient as to produce Wallerian degeneration and only slight endoneurial collagenization, then spontaneous recovery may be expected in the nerves so affected.

## REFERENCES

- ADAMS, W. E. (1942), *J. Anat.*, **76**, 323.  
 — (1943), *Ibid.*, **77**, 243.  
 BARKER, N. W. (1938), *Arch. intern. Med.*, **62**, 271.  
 DOINIKOW, B. (1913), *Dtsch. Z. Nervenheilk.*, **46**, 20.  
 FOISIE, P. S. (1942), *New Eng. J. Med.*, **226**, 671.  
 GRIFFITHS, D. L. (1940), *Brit. J. Surg.*, **28**, 239.  
 GUTTMANN, L. (1940), *J. Neurol. Psychiat.*, **3**, 197.  
 — and MEDAWAR, P. B. (1942), *Ibid.*, **5**, 130.  
 HOLMES, W., and YOUNG, J. Z. (1942), *J. Anat.*, **77**, 63.  
 HORWITZ, T. (1942), *Surg. Gynec. Obstet.*, **74**, 871.  
 LAPINSKY, M. (1898), *Dtsch. Z. Nervenheilk.*, **13**, 468.  
 — (1899), *Ibid.*, **15**, 364.  
 LEARMONTH, J. R., personal communication.  
 MARCUS, H. (1933), *Acta psychiat.*, *Kbh.*, **8**, 297.  
 MEYERDING, H. W. (1930), *J. Amer. med. Ass.*, **94**, 394.  
 PANČENKO, D. I. (1941), *Arch. path. Anat.*, **307**, 327.  
 PRIESTLEY, J. B. (1932), *J. nerv. ment. Dis.*, **75**, 137.  
 RICHARDS, R. L. (1943), *Edinb. med. J.*, **50**, 449.  
 SANDERS, F. K., and YOUNG, J. Z. (1944), *J. Physiol.*, **103**, 119.  
 SEDDON, H. J. (1943), *Brain*, **66**, 237.  
 THOMAS, J. J. (1909), *Ann. Surg.*, **49**, 330.  
 WEDDELL, G., FEINSTEIN, B., and PATTLE, R. E. (1943), *Lancet*, **1**, 236.  
 WOLTMAN, H. W., and WILDER, R. M. (1929), *Arch. intern. Med.*, **44**, 576.

## SURGERY IN AN AIRBORNE DIVISION

By C. J. LONGLAND AND LIPMANN KESSEL

In the present war airborne troops have made their debut. They take advantage of the new developments in air transport, and to serve them specialized medical units which can provide a surgical service have been formed. Airborne troops are to be distinguished from other unspecialized troops which on occasion may be transported in aircraft or gliders, in that they are designed and trained to use aircraft and gliders as their chief means of transport, usually descending from the aircraft by parachute; and they are trained to exploit this peculiar advantage to the full.

This communication is intended to give as comprehensive an account as possible of the present surgical service in a British Airborne Division. Since the operative technique of forward wound surgery can be varied but little, the account is concerned chiefly with the special conditions existing in an airborne force in which such surgery must be carried out.

The provision of a surgical service for an airborne force may at times be a difficult undertaking, more difficult than forward surgery in

general since many of the adverse factors tend to be considerably intensified, and much depends on local circumstances. It is a far cry from the atmosphere of a very much improvised forward operating centre to that of the wards and theatres of a static hospital, and the surgeon's outlook must alter accordingly. Asepsis and mud may be room-mates; clean areas must be jealously guarded from the inroads of unfavourable surroundings; slender resources must be carefully husbanded; technique must be kept simple while principles are obeyed, and nursing is beset with difficulties, real comfort being almost out of reach. On the other hand, the patients are young, fit soldiers of good physique to whom absence of comfort is no novelty.

## HISTORY

The earliest stages in the development of airborne troops were concerned with the formation of small parachute units whose function was to be dropped as raiding parties for doing demolitions and sabotage work in enemy territory

For these small and scattered parties first aid was all that could be attempted by the R.A.M.C. personnel attached to them. As a result of the experience gained with them, it became possible to build up larger units, sufficiently powerful to carry out tactical plans as part of a larger force of all arms. This process has been continued till the present complete airborne divisions have emerged, capable of descending in strength in enemy territory and occupying areas of ground. Once the stage had been reached at which an airborne force could seize and hold a position of some size, it became possible to supersede first aid by forward surgery carried out by teams forming part of the force; where the nature of the operation made rapid evacuation impossible surgery became imperative. Consequently at this juncture surgical teams were added to the medical organization.

From the start two methods of delivering troops by air were employed: on the one hand, men and light equipment were dropped by parachute; and on the other, men and heavier equipment were landed in gliders. Both these methods have been developed and are used in combination, heavier equipment being available where gliders can be used.

The airborne medical units were designed on a brigade basis, and became Airborne Field Ambulances, their establishment providing for two surgeons in each Field Ambulance. It was at first proposed that the surgical equipment should be carried by the sections of the Field Ambulance, and when conditions seemed favourable a surgeon would accompany the section. This arrangement had many disadvantages, and the surgical equipment was transferred to the surgeon and five men, who formed a surgical team within the Field Ambulance.

At this stage it fell to a parachute surgical team and Field Ambulance section, commanded by Major (then Lt.) C. G. Robb, M.C., and Capt. D. Wright, M.C., to carry out the first operation on active service. They dropped with a parachute battalion which seized the town of Beja at the commencement of the Tunisian campaign. They were able to set up in a small hospital and to do excellent work, using their own equipment entirely, since the hospital boasted little technical equipment of use. They performed 137 operations on military cases, including 8 abdominal and abdomino-thoracic wounds with visceral damage, and had only 1 death before evacuation, a case of gas gangrene in a limb wound received late. The experience gained from this operation was of the greatest value, since it gave practical proof of the thesis that forward surgery could be provided for parachute formations within the limitations imposed by their method of movement. The Airborne Surgical Team had definitely been put on the map.

As the Tunisian campaign progressed it was found necessary to employ parachute troops as ordinary infantry, and during this period more

experience was gained in the use of the surgical equipment while working with it in various normal dressing stations. Some rearrangement and improvement of organization and equipment suggested during this period was carried out at the close of the campaign.

Larger forces of airborne troops were employed for the invasion of Sicily than had been previously used. A gliderborne formation was used in the initial assault, taking a Field Ambulance with it. For various reasons the troops became very scattered and little scope was

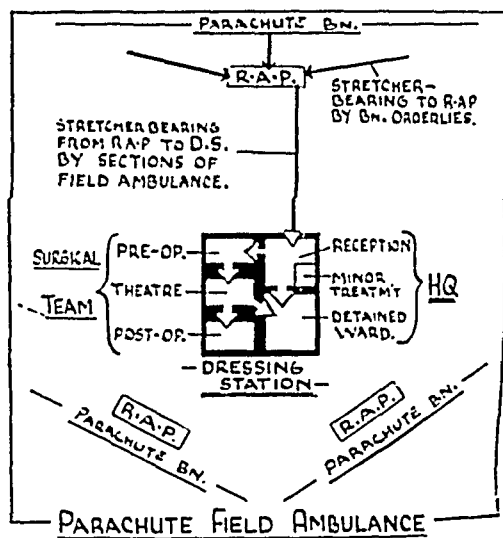


FIG. 195.—Schematic layout for a classical role in a defended perimeter, where no evacuation is possible initially.

afforded to surgery. A few days later a parachute formation was dropped ahead of the advancing ground troops and seized an important position. An operating centre was set up as part of the Field Ambulance Main Dressing Station in a building at the foot of a hill inside the parachuteists' position; it worked to capacity, though at one time as a result of vigorous counter-attacks the parachute infantry were defending only the hill behind it. On the arrival of the ground troops 36 hours later the cases were successfully evacuated. Thirty-five cases were operated on with 2 post-operative deaths, the remainder arriving at Base hospitals in good condition. This operation marked an advance in the activities of the airborne medical services, for a complete operating centre with all the required departments was run satisfactorily in the course of a parachute operation conducted behind the enemy's forward troops.

### PECULIAR PROBLEMS

Airborne troops have three important characteristics out of which a number of problems arise. First, though great long range mobility is one of their outstanding assets, once on the ground

they are relatively immobile, because the amount of motor transport they can take with them or capture is small, and they must depend on themselves for movement. Secondly, because of the lack of motor transport and of the limited loads which the aircraft can carry, the amount of equipment they can command is strictly limited. Thirdly, in their most typical type of operation they fight inside enemy territory and have no rearward ground communications.

The first of these characteristics favours the use of operating centres which are necessarily static affairs once established, for frequent moving of such centres is extremely uneconomical. The second characteristic governs the difficult choice and packing of equipment. In working out details of equipment other factors beside total weight must be considered. In the case of parachute troops, loads must be designed, each of which can be carried by one man in order to enable rough country to be crossed on foot. Furthermore, their loads must fit in to the containers in which equipment is carried by the aircraft. The containers are cylindrical in shape, carried in bomb racks beneath the aircraft, and on release open a parachute which lands them, often with a considerable jar (*Fig. 196*). These

heavier equipment with less restriction as to size and shape; but their increased capacity must be utilized in the first instance to carry larger quantities of stretchers and blankets, needed everywhere throughout the medical service. The lack of heavy equipment, mainly furniture, beds, bedding, and tentage must be made good by improvisation, and here ingenuity and resource play a great part.

The third characteristic mentioned above, i.e., the role of airborne troops behind enemy lines, is the most important of all. Under such conditions evacuation of casualties to rearward hospitals is impossible for some time, usually to be measured in days, and surgery must be provided by the medical unit concerned if wounds are to be operated on within a reasonable period. As a corollary, adequate nursing must be available to secure good results from surgery. Until the airborne troops join up with the ground troops and evacuation can take place, the wounded must accumulate in the dressing station; if fighting is severe the number may reach a total which taxes its resources to the limit. In this type of operation, it may be impossible to place the operating centre out of range of even the lighter weapons, but this disadvantage can be reduced to comparative unimportance if the site is carefully chosen, with the maximum natural protection and away from likely targets; added protection is afforded by the use of the Geneva Cross. Such a situation need not prevent the work of an operating centre.

### OPERATIONAL METHODS

How useful a surgical team may be on any particular operation depends on whether the force intends to hold an area for a sufficiently long time to make it practicable to establish an operating centre, and whether the force will be isolated. If no evacuation is possible, then the teams will be needed even for a short operation of a day's duration.

In planning for an operation, information is required about buildings and communications in the area, particularly in the form of aerial photographs. Alternative buildings are chosen as sites for an operating centre as far from likely targets as possible, but accessible to casualties from all units. The equipment to be taken varies slightly according to such considerations as the number of men available to carry it, the number of gliders taking part, the accessibility of the landing zone in the later stages of the operation, and the arrangement for the provision of further supplies. Loading tables and rendezvous after the landing are arranged accordingly, and everyone taking part is carefully briefed. It is essential that every man shall have as much information as possible, since some men may become separated at the time of the landing, and must depend on themselves to do their initial job of arriving with their equipment at the right place at the right time.



FIG. 196.—Equipment packed in a parachute container for dropping from a bomb rack.

conditions preclude taking tentage or furniture other than the lightest of folding trestles and stretchers. There is another important consideration to be taken into account. There is always a likelihood that a proportion of the equipment despatched from the airfield will not arrive at its destination; there must, therefore, be sufficient duplication of essential items and careful distribution of items between loads, to minimize as far as possible the loss of some loads.

Selection and packing of equipment is the thorniest of the problems. It is eased to some extent where gliders are used, for they can take

The surgical teams generally consist of a surgeon and five orderlies with another medical officer or dental officer attached as anæsthetist. An orderly for work in the pre-operative and resuscitation department, and more for work with

landed behind our own front lines as reinforcements, the teams can go to the selected site and set up in consultation with the ground units. Evacuation of casualties and supply will be arranged with the other medical services in the area on usual lines.

By the time that the operating centre is ready to function, the teams will have already done a considerable amount of physical work. In the preceding period they have loaded their aircraft, they may have done a long flight ending with a parachute descent, and then marched with heavy loads over difficult ground, possibly under fire. The building used will have needed cleaning and re-organization. All this may have taken place at night with the loss of much sleep, so that after even a short period of operating rest becomes imperative. It is wise, therefore, if conditions permit, to arrange short, alternate initial shifts for the teams.

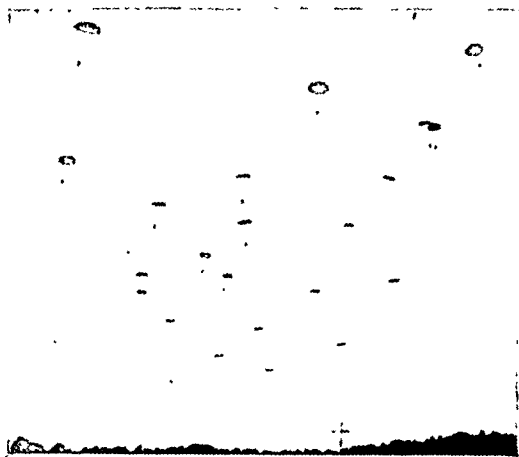


FIG. 197.—A parachute landing.

severe cases in the post-operative ward may also be added to the team, and as a rule two such teams work in conjunction. The teams are not able to manhandle all their equipment and a number of men required for other duties in the Main Dressing Station at which the teams will work, travel in the same aircraft and assist in transporting the equipment on the ground. When the day of the operation arrives, the teams take off with the rest of the formation in troop-carrying aircraft and drop with the other units (*Fig. 197*), or land in gliders if part of a gliderborne force. In the case of parachutists their equipment is dropped on the men (*Fig. 198*) or in the containers. After the landing the medical personnel assist men injured on landing. Such casualties in a parachute force are liable to occur when any considerable numbers of men are dropped; if weather conditions are good their numbers are very small, but with increasing wind speeds landings become heavier and casualties increase. Some gliders, too, are likely to be damaged on landing and their troops may sustain injuries. The Surgical Teams take no special part in dealing with these casualties.

The landing may take place in darkness and only as a result of careful training is it possible to collect men and equipment together, and contact the troops at the rendezvous. This place may sometimes be difficult if the 'drop' is made at some unknown point outside the pre-arranged landing zone, when an awkward problem in orientation presents itself. If the force has been landed in enemy-held territory the men, with their loads, must make their way in the wake of the infantry as it seizes its positions, lying up when necessary, till the area of the chosen building has been cleared. When the formation has been



FIG. 198.—Equipment may be packed in a kit bag attached to the parachutist's leg and released on a length of rope during the descent.

## SURGICAL METHODS

**Theatre.**—The aim is to provide the full recognized Forward surgical treatment for all types of casualties, such surgery being directed towards making the patient safe and comfortable for the journey to Base hospitals, and giving the

wounded tissues the best chance of rapid and complete healing. Since the requirements of Forward surgery are essentially simple, this aim is feasible, and in the two parachute operations in which this has been tried the object has been fully attained. Such work differs little from that of the ground Field Surgical Units. The fact that on certain operations evacuation will be delayed for a few days only modifies the attitude to be adopted on these occasions in a few special types of wounds, notably that of the penetrating head injury. If there is no possibility of getting the case back to a neurosurgical unit at once, then a thorough excision of all tissues outside the dura must be done, and as much debris and fragmented bone removed from the track in the brain as possible. This is in contrast to the usual Forward procedure of conservative surgery and rapid evacuation to a specialist unit.

The keynotes of the theatre procedures are simplicity and rigid routine. This makes for rapid work and gives the best chance of maintaining asepsis in difficult conditions.

Some of the bulkiest stores of an operating theatre consist of linen, and a good deal of work is needed to launder it. Jaconet is used instead, and offers several advantages under field conditions; it is easy to clean and can at once be sterilized by boiling; by shaking the jaconet towel directly it is removed from the boiling water it becomes fairly dry. Since it is waterproof, even if placed on a dirty surface no contamination will soak through and render its upper surface unsterile. At first it is unpleasantly sticky to use, but after being boiled a few times it improves. The yellow colour of jaconet is made a sign of sterility and sterile areas are easily so marked and recognized. Use is made of large pieces of red rubber sheeting to protect the underlying blankets during the preparation of the wound area. Its presence in position beneath a limb or other part of the body indicates that the wound areas have been prepared by washing the skin with soap and water and by shaving. It is then only necessary to paint the skin surrounding the wound with tincture of iodine and to place the yellow jaconet towels, which show up very clearly against the red sheeting, before commencing the operation.

When dealing with the lighter cases, two men of the five in the theatre carry out the preparation of the succeeding case on the lines set out above. They do this preferably in the same room as the surgeon, which enables the anaesthetist to give anaesthesia during the preparation if required and the surgeon to exercise some supervision of the work. In many cases it takes just as long to remove sufficient clothing and prepare the wound area as for the operation. The two men doing the preparation endeavour to keep a light case in reserve ready prepared, known as the 'stand-by' case. He is chosen from among the cases who will come to no harm by waiting for some hours. When a major case,

such as an abdominal wound, requires operation, all five men in the theatre are ready to assist. The 'stand-by' case will be dealt with after the major case while another case is being prepared for operation.

Various minor modifications of routine have been tried in the method of providing instrument sets for successive cases. A satisfactory method has been christened the 'two-bench circuit'. The first bench or table is divided into two portions; on the one part are put the containers of all the sterile requirements, with the exception of articles sterilized by boiling, to be drawn upon continuously for the series of cases. On the other part are put the trays containing the sterilized instruments and towels for the next case. Everything on this first bench is therefore sterile. After use the dirty instruments, towels, and bowls are returned to one end of the second bench, cleaned and transferred to an area on their right, and so completes the circuit. If two rooms are available for the theatre the sterile bench stands in the operating room and the other bench in the sterilizing room.

The instruments carried by each team are sufficient to provide two wound excision sets; additional instruments enable one such set to be expanded for abdominal or bone work; with the addition of the dental instruments carried by the dental officer of the Airborne Field Ambulance they are suitable for the primary surgery of nearly all the wounds encountered. The main ligature material is No. 60 linen thread, which is boiled with the instruments and is reliable and extremely economical. Atraumatic catgut for intestinal work and silkworm gut are also carried.

Lighting is provided by paraffin pressure lamps with incandescent mantles which give a fair general light, by electric head lamps, and by accumulator-operated spot lamps on stands. Recharging of accumulators can be done by the charging dynamos carried by the Royal Corps of Signals.

Pentothal sodium has gone a long way towards making good and pleasant anaesthesia possible in the field for the majority of cases without the necessity of heavy and bulky apparatus, and is therefore most suitable for airborne work. Open ether is a dangerous supplement in the unavoidable presence of naked flames from stoves or lamps and for this reason has been abandoned in favour of chloroform which has the further advantage of being less bulky than ether. Local anaesthesia finds its best use for head and chest cases.

It is unfortunate that as yet there is no light and strong plastic to replace plaster-of-Paris. For airborne work when bulk and weight must always be minimal, plaster-of-Paris is not ideal, and it is difficult to supply sufficient quantities of this essential item. The casts used are based on three standard patterns for each limb; these are the 'box' plaster, the full arm plaster, and a roller splint to hold wrist, hand, and digits in



the functional position for the upper limb; the simplified 'Tobruk' plaster, the full leg plaster, and the lower leg plaster for the lower limb.

**Pre- and Post-operative Wards.**—Resuscitation is the responsibility of the surgical team when it has a specially trained orderly attached to it for this purpose. Additional help is given by the staff of the Main Dressing Station, and the resuscitation is done in the pre-operative ward to which all cases for operation are sent from the reception department.

Insistence is put on the arrest of bleeding and a supply of shell dressings and of gauze rolls in flavine is kept ready for those wounds which the previously applied first aid has not adequately controlled. Blood-pressures are recorded with an aneroid type of sphygmomanometer. The pump and the recording gauge have supplies fitted to them by which they can be transferred from cuff to cuff, and the small size of the gauge makes it a very convenient instrument. Warmth is provided by chemical 'hot-water bottles', of which a large supply is carried. The addition of a small amount of water to the chemical in the rubber bag produces more constant warmth than a hot-water bottle for a longer period. Fluid in the form of hot tea is given freely until the time of the pre-operative injection of omnopon (gr.  $\frac{1}{2}$ ) and scopolamine (gr.  $\frac{1}{16}$ ), which is given to every case unless already deeply morphinized, in which case atropine is substituted.

The standard Army pattern transfusion apparatus is used for giving plasma, which is given at once if the blood-pressure falls to 80 mm. of mercury, but is withheld till the effect of rest has been determined if the pressure is above this figure, unless the severity of the wound makes

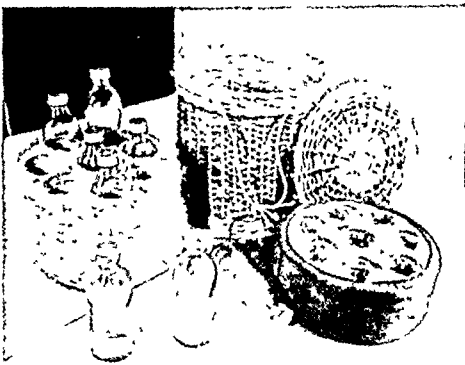


FIG. 199.—Plasma basket, holding eight bottles of wet plasma, which can be dropped in a parachute container.

transfusion imperative. The plasma is carried in liquid form instead of as the dried product for economy of space, since the additional bottles of distilled water are dispensed with (Fig. 199). It has not been possible to carry blood in the past owing to the difficulties of refrigeration and reliance has been put on volunteers from among

the Group O's of the staff. Lack of adequate supplies of this valuable fluid is keenly felt and it is hoped that it may shortly be available.

Most surgeons are agreed that it is easier to do satisfactory operative work than to ensure satisfactory post-operative nursing in the Forward

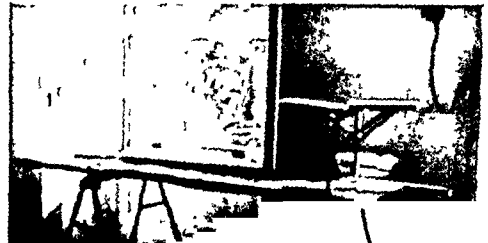


FIG. 200.—Collapsible airborne pattern stretcher, trestles, and instrument overtable ready for use as an operating table.

Area, and this is particularly true in the airborne units. The gravest problem in nursing the severely wounded cases is absence of beds. Stretchers are used if no beds are found locally. The stretcher used by airborne troops is light and of collapsible steel construction, and it has the great advantage over the standard type that by partially folding it a back-rest can be devised (Fig. 200). Sheets, naturally, are out of the question, but blankets can be provided for the severe cases. As far as possible, the patients' clothing must be conserved, as many of the cases are likely to have little else for covering. Apart from such local facilities as happen to exist little can be done to provide for washing of the bed cases, and feeding has to be carried out with the patient's mess-tin and rations. The 24-hr. ration issued for airborne operations is very suitable for feeding patients, since it contains plenty of chocolate and sweets, besides tea and beef extract. The nursing of cases where evacuation is impossible calls for much ingenuity and hard work on the part of the orderlies.

The provision of glucose-saline for intravenous fluid administration is again a somewhat difficult matter, since considerable amounts in weight and volume are required. Pure glucose is packed with the equipment taken on the initial drop; it is intended to be used rectally, but if necessary it would be given intravenously in boiled water if the situation demanded it. A limited amount of 5 per cent glucose-saline solution is taken.

Gastric suction is provided for by including Ryle's tubes in the equipment, and fairly efficient suction apparatus can be devised from transfusion apparatus.

The vast majority of war wounds provide no special problems peculiar to the surgeon in an

airborne unit. The clinical problems which do require special attention are the types of operation to be performed on those cases which, though best sent to specialist units, may have to be retained; facilities for post-operative nursing, particularly of abdominal cases; and the difficulties arising from working with limited amounts of transfusion fluids and plaster-of-Paris. This last difficulty will be eased by recent improvements in supply methods.

### CONCLUSION

The surgeon in an airborne unit often works with one advantage: the time-distance lag in receiving casualties after wounding tends to be shorter than is generally the case. This is due to the fact that the operating centre on some occasions is likely to be located close to the infantry positions, and also to the provision of R.A.M.C. personnel for each infantry company in an airborne battalion, so that casualties are cleared back rapidly. For this reason severely wounded men may be expected to reach the

surgeon when in other circumstances they would not have done so. An experienced surgeon who dealt with casualties from a Parachute Brigade in Tunisia remarked that he had not seen such severely wounded men brought back for operation in any other sector of the front.

Though airborne surgical teams have had few opportunities for work in airborne roles, it is none the less true that the surgical services have not lagged behind the modern development of airborne forces. There have been doubts as to whether this could be attained, but the basic principle has now been established that it is possible to give isolated airborne troops the benefit of early wound surgery.

The assistance given us by Brigadier A. Austin Egger, C.B.E. (R.A.M.C.) in compiling this account of work, which was carried out very largely under his guidance, is acknowledged.

Our thanks are due to Lieut.-Colonel E. Townsend, M.C., R.A.M.C., for permission to publish this article.

## THE CLINICAL VALUE OF A GROWTH-PROMOTING SUBSTANCE IN THE TREATMENT OF INDOLENT WOUNDS

BY LIEUT.-COLONEL A. B. KERR, R.A.M.C., AND LIEUT. H. WERNER, R.A.M.C.

FROM THE SURGICAL DIVISION OF A MILITARY GENERAL HOSPITAL

INDOLENCE in ulcers and wounds has been a major drain on the man-power of the armies in the Middle East, and has been responsible throughout the campaigns there for a very significant proportion of the admissions to Military hospitals. Several official memoranda and many contributions to medical journals have dealt with different aspects of the indolent ulcer and wound and have advocated a variety of methods of treatment with varying degrees of confidence. The staffs of many Military hospitals have attempted to assess the value of these various methods, but all have found difficulty in arriving at any opinion which could be supported by more than clinical impression or statistically insignificant figures. Such a series of observations was made in this hospital in 1941 and 1942, each surgical specialist adopting a different standard method of treatment. Despite the large total number of lesions treated, it was not found possible to collect significant numbers of comparable cases. Such variable factors as the size, type, and duration of the lesion, previous treatment, nutritional state of the patient, and the nature and severity of infection appeared to invalidate any statistical conclusions. Each method, however, showed a considerable proportion of cases in which progress was extremely slow or was interrupted by periods of total inactivity or even of regression.

It was against this background that there became available to us through the Department of Experimental Pathology of the Hebrew

University, Jerusalem, a tissue extract known to possess the property of stimulating growth in tissue cultures. The growth-stimulating property of such a substance in the treatment of wounds can be assessed by animal experiment or clinically. Even under experimental conditions which can be fully controlled in respect of the standardization of the animal used, and the size and site of the wound inflicted, a series of considerable size must be studied if biological variations are to be eliminated. As it appeared quite impracticable to obtain such a series in man, it was determined to confine the use of the tissue extract to lesions which had failed to heal despite treatment under the personal care of the surgical specialists to the hospital, and to accept as successful only such cases as progressed to complete healing within a reasonable time. The proportion of lesions which fail to heal under a selection of the standard treatments applied over a period of several weeks is not high, and the strict application of the method of selection described led to the relatively small size of the present series. It is, however, considered more significant than a larger series in which less exacting evidence of indolence is accepted. As the work progressed we have seen fit to add to the series non-healing burns which fulfil the same criteria of selection.

The well-being of the individual patient has necessitated the use of additional methods, notably skin-grafting, on many non-healing

lesions, especially on extensive burns. Attempts to combine the use of the extract with skin-grafting have been made, and it is considered that a method has been arrived at which is of practical and theoretical importance.

It is regretted that military exigencies necessitate the closure of the present series of observations. Though the series remains small, it is yet considered adequate to justify the adoption of this therapeutic substance for selected cases and the exploration of additional fields of application which suggest themselves.

**The Substance.**—Carrel and Burrows (1911) were the first to show that saline extracts of proliferating tissues added to a culture medium lead to an increase in the growth rate of cell colonies *in vitro*. According to Carrel (1913) the property of activating cell growth *in vitro* is particularly high in embryonic extracts. His experimental observation led him to envisage the acceleration of normal healing in wounds by the use of such substances (1913). Those who have attempted to apply the clinical test to this postulate have met with a series of difficulties: (1) The extract could not be produced in large quantities. (2) The extract was unstable and very susceptible to bacterial contamination. (3) Civilian surgery offered very inadequate series of wounds.

The first of these difficulties was overcome in 1939, when Doljanski and Hoffman showed that extracts of certain adult tissues were even more active in growth-stimulation *in vitro* than was embryonic extract. Further experiments of Doljanski, Hoffman, and Tenenbaum (1942) have shown that the action of adult tissue extracts is exerted not only on connective tissue but also on epithelium in cultures of human skin.

The second difficulty was overcome when Werner and Doljanski in 1942 produced a growth-promoting substance in the form of a powdered preparation of sheep's heart. In the preparation of the powder, minced heart muscle of the sheep is extracted with four times its weight of normal saline for several hours in the refrigerator. This aqueous extract is mixed with double its weight of 96 per cent alcohol and, after centrifugalization the deposit is dried *in vacuo* over calcium chloride. The dried substance is ground and the resulting powder extracted with ether. After further grinding the substance is ready for use. This powder retains indefinitely its growth-stimulating property toward tissue cultures and, if kept dry, is not readily contaminated. The present paper represents an analysis of our clinical experience with this heart-extract powder, referred to in case notes below as H.E.P.

### H.E.P. IN NON-HEALING LESIONS

Lesions treated in this group fall into three categories in respect of their primary causation: (1) Ulcers with or without preceding trauma or acute inflammation; (2) Wounds by projectiles; (3) Burns. On admission to this

hospital all the patients were first treated on orthodox lines and the majority had previously received similar treatment in other Military hospitals. At the discretion of the surgical specialist concerned this treatment consisted of occlusive elastic dressings, sulphanilamide powder with tulle gras, vaseline dressings, plaster-of-Paris, flavine dressings, skin-grafting, or other similar methods alone or in combination. All the patients received a high-protein diet rich in vitamins. Only when such treatment had been applied for at least three weeks, and usually for much longer, under the personal direction of a surgical specialist and no further progress could be achieved was a patient accepted for treatment with heart extract powder. Patients in whom delay in healing could be attributed to a retained foreign body, bone infection, continued chemical necrosis following paravenous injection of quinine or the presence of deep sinuses, were not accepted until such had been eliminated and a further period of orthodox treatment given without success. No lower limb lesion was accepted unless total rest for an adequate period had been an essential part of the previous treatment.

In their appearance and in their response to H.E.P. it appeared of no significance whether the lesions had been initiated by an abrasion, a wound, or a burn, or had arisen *de novo* as 'desert sores'. All presented the common characteristics of infected non-healing ulcers in which the failure to heal was not due to any recognizable factor and could not be overcome by orthodox therapy.

**Technique.**—No alteration in the general treatment of the patient was made. The lesions were dressed daily or on alternate days. They were gently cleaned with saline. H.E.P. was then lightly sprinkled on, and the lesion covered with gauze soaked in saline or lightly impregnated with vaseline.

The outline of all wounds was traced on sterile cellophane and their area thus measured with the planimeter.

**Results.**—A total of 36 cases fulfilling our criteria of intractability to orthodox methods were accepted for treatment; 33 of these have fulfilled our criteria of success. Only 3 cases (Cases 34, 35, and 36) failed by showing no response or only a partial response. Not included in these figures are the six patients still under treatment, all of whom appear certain to be classified as successes. Experience has disclosed to us no other method or combination of methods which could conceivably have led to the healing within the periods quoted of over 90 per cent of these 36 orthodox failures. Within one week of the commencement of treatment a development of fresh pink granulations was usually to be noted on the base of the wounds. This was accompanied or immediately followed by obvious epithelial spread from the margins. Thereafter healing proceeded normally and the ultimate scars presented no unusual features.

## BRIEF CASE RECORDS

*Case 1.*—H. B. Developed an unexplained chronic ulcer over skin. Transferred to this hospital 35 days later. Treated for 116 days with occlusive dressings, eusol, and plaster-of-Paris without success. Ulcer (7 sq. cm.) healed in 16 days with H.E.P.

*Case 2.*—J. P. Developed an ulcer on lateral aspect of upper leg on the scar of a recent small burn, followed by a second larger ulcer in popliteal fossa. Treated in various hospitals and transferred to this hospital on 85th day. Treated for 82 days with eusol, sulphanilamide, saline baths, and sodium sulphate without improvement. Edges were much undermined. The area of granulation measured 39 sq. cm. Under H.E.P. healing commenced from such edges as were not undermined and from a surviving island of epithelium, and was complete in 60 days, the undermined edges being excised at a late stage.

*Case 3.*—E. A. E. Developed an ulcer following a furuncle on upper leg. Admitted to this hospital after 50 days. Treated for 74 days without success by eusol, sodium sulphate, saline, and pinch-grafting. Ulcer (6 sq. cm.) healed in 20 days under H.E.P.

*Case 4.*—F. S. Developed chronic ulcer following a scratch on medial side of upper leg. Admitted to this hospital after 120 days. Treated with sodium sulphate and sulphanilamide with no progress whatsoever for 21 days. The ulcer (21 sq. cm.) healed in 32 days under H.E.P.

*Case 5.*—W. M. Three months before admission treated for varicose veins by injection, followed probably by thrombophlebitis. Transferred to this hospital where an ulcer was first noted. This ulcer ineffectively treated for 54 days with saline, sulphanilamide in vaseline, and urea. The ulcer (3.5 sq. cm.) healed in 10 days under H.E.P.

*Case 6.*—F. S. Ulcer developed on leg following a furuncle. Admitted to this hospital after about 35 days. Treated for 36 days with eusol, sulphanilamide, cauterization with silver nitrate, and plaster-of-Paris fixation without success. The ulcer (14 sq. cm.) healed in 39 days with H.E.P.

*Case 7.*—W. M. Developed an ulcer at the site of a hæmatoma of leg. Treated with sulphanilamide powder, and acriflavine in oil for 50 days without improvement. The ulcer (29 sq. cm.) healed under H.E.P. in 18 days.

*Case 8.*—J. W. Developed an ulcer in the popliteal fossa following a furuncle. Admitted to hospital after about 14 days. Treated with sulphanilamide powder and sodium sulphate for 67 days without progress. The ulcer (2 sq. cm.) healed in 8 days under H.E.P.

*Case 9.*—N. H. H. Developed ulcer on lower leg on site of old burn. Admitted to hospital within a few days. The ulcer was, however, already indolent when he developed very severe typhoid fever. During his prolonged recovery period no alteration occurred in the ulcer. The ulcer (10 sq. cm.) healed in 13 days under H.E.P.

*Case 10.*—W. G. Developed ulcer on left flank following carbuncle for which he was treated in this hospital. The ulcer failed to heal on glycerin and sulphanilamide and pinch-grafting for 48 days. The ulcer (16 sq. cm.) healed in 39 days under H.E.P.

*Case 11.*—C. R. Admitted with ulcer over lower shin of unknown cause. Failed to respond to sodium sulphate and sulphanilamide for 42 days. The ulcer (7.5 sq. cm.) healed in 21 days under H.E.P.

*Case 12.*—B. P. Developed an ulcer on forearm following a mosquito bite. Treated ineffectively for 79 days with sodium sulphate and sulphanilamide powder. The ulcer (15 sq. cm.) healed in 40 days under H.E.P.

*Case 13.*—D. H. N. Ganglion excised from dorsum of toe. In 35 days wound failed to advance in healing. The ulcer (1 sq. cm.) healed in 13 days under H.E.P.

*Case 14.*—A. S. Ulcer developed on site of furuncle. Failed to respond to flavine, sulphanilamide, and sodium sulphate dressings over a period of 90 days. The ulcer (2 sq. cm.) healed in 10 days under H.E.P.

*Case 15.*—A. W. Shell wound of leg in which gas gangrene was suspected. Transferred to this hospital 5 days after wounding. Residual ulcer treated with sulphanilamide with tulle gras, and plaster-of-Paris without success for 112 days. The ulcer (8 sq. cm.) healed in 35 days under H.E.P.

*Case 16.*—W. G. Bullet wound of antecubital fossa. Transferred to this hospital 14 days later. Treatment for 102 days with plaster-of-Paris and sulphanilamide left a totally indolent ulcer. This ulcer (2 sq. cm.) healed in 17 days under H.E.P.

*Case 17.*—A. M. Shell wound of thigh. Transferred to this hospital 14 days later. The residual ulcer was treated for 136 days with sulphanilamide powder and 3 pinch-graftings all without success. The ulcer (13 sq. cm.) healed in 13 days under H.E.P.

*Case 18.*—L. R. Bomb wound of thigh. Transferred to this hospital after 12 days. Residual ulcer was treated for 113 days with sulphanilamide and pinch-grafts without success. The ulcer (3.8 sq. cm.) healed in 19 days under H.E.P.

*Case 19.*—G. G. Bomb wound of back muscles. Transferred to this hospital after 12 days. Partially successfully secondary suture left a residual indolent ulcer. This was treated for 62 days with pinch-grafts and sulphanilamide without success. The ulcer (2 sq. cm.) healed in 15 days under H.E.P.

*Case 20.*—H. S. Mine wounds of thigh. Transferred to this hospital after 27 days. Residual ulcer in largest wound treated for 44 days with eusol and sulphanilamide without success. The ulcer (2.7 sq. cm.) healed in 14 days under H.E.P.

*Case 21.*—A. B. Shell wound of calf. Transferred to this hospital after 46 days. The residual ulcer was treated for 47 days with tulle gras and plaster-of-Paris without success. This ulcer (4 sq. cm.) healed in 21 days under H.E.P.

*Case 22.*—E. C. Shell wound of calf. Transferred to this hospital after 46 days. The ulcer was treated ineffectively with tulle gras and plaster-of-Paris for 55 days. The ulcer (6 sq. cm.) healed in 8 days under H.E.P.

*Case 23.*—E. W. Shell wound of thigh. Transferred to this hospital after 46 days. Progressive

benefit of the biological assay of a wound-healing substance to those wounds which persist in their indolence, either not healing at all or healing very slowly, after surgical skill has eliminated or adjusted as far as possible every recognizable local retarding factor."

Our conception of indolence in non-healing wounds has been the failure or total arrest of healing under intensive orthodox treatment in the absence of any local cause, a situation of stalemate being established between the constructive tendency to heal and the destructive factors, including infection. The present series indicates that in a large proportion of such indolent wounds the application of heart extract powder serves to turn the balance in favour of the constructive healing tendency.

A series of clinical cases treated by Mandl and Maybaum (1943) records a high proportion of successes with heart extract.

Incidental to the main thesis that growth-stimulating substances are of value in the healing of wounds in man, a number of observations have been made which appear of theoretical and practical importance. The conclusions to which these observations lead are here included as postulates which may or may not be substantiated by the further work now planned:—

1. The quantitative tendency to heal is at least in part a function of the body as a whole.

In multiple wounds, healing and non-healing tends to occur in all wounds simultaneously. In the few cases where we have been able to apply H.E.P. to one of several coexistent indolent wounds the process of healing resulting in the treated wound has been accompanied by the commencement of healing in the others. It appears likely to us either that the growth-stimulating substance has been absorbed at the primary wound or, as Young, Fisher, and Young (1941) suggest, that a growth-stimulating substance is liberated in the course of healing.

2. The augmentation of the tendency to heal by growth-stimulating substances may lead to an improvement in the general condition.

It will not be disputed that the improvement of a patient's general condition by rest, adequate nourishment, and when necessary blood transfusion, tends to be followed by an improvement in the local condition of his wounds. That the reverse process may occur is suggested by our experience with at least one patient in whom the application of H.E.P. to non-healing burns was followed by rapid healing and by a most striking improvement in general condition. As his burns have not yet finally healed he is not included in the main series.

D. L. Aged 27. On Nov. 13, 1942, sustained extensive petrol burns of both legs and thighs, right side of face, and right arm. On transfer to this hospital on May 22, 1943, his general condition was very poor; he was emaciated and febrile and had no appetite; his burns showed no active healing. For nine weeks in this hospital he was treated by local

application of sulphanilamide and by high-protein diet without any alteration in the local or general condition. Blood transfusions given at intervals of ten days served only to maintain his hæmoglobin level at 65 per cent. Dressing with large quantities of H.E.P. was commenced 297 days after burning. Within six days epithelialization was evident in all areas. At the same time his appetite rapidly reached quite abnormal heights and the most striking improvement in his mental outlook occurred. Though no further blood transfusions were given his blood-count and hæmoglobin level became normal within one month and have remained so during the subsequent healing and grafting of his wounds.

3. The 'take' of pinch-grafts depends on the local tendency to heal at the time of their application.

From a considerable experience of failure and success in pinch-grafting, we came to regard the clinically observed balance between reparative and destructive processes in a wound as of greater value in prognosis than the bacteriological findings. This is supported by the subsequent observation that grafts will take in an area where a few days previously they had failed, the only recognizable modification being the establishment of a tendency to heal by the application of H.E.P.

## SUMMARY

1. A stable dry preparation from adult heart muscle possessing the property of stimulating cell growth was used in the treatment of indolent lesions in human subjects in whom prolonged treatment by various orthodox methods had proved unavailing. The great majority responded favourably to the new treatment and closure of the wounds was achieved in relatively short time.

2. Observations have been made which suggest that preliminary treatment with this substance improves the 'take' of transplants in skin-grafting.

3. Certain theoretical considerations regarding the mode of action of the preparation are discussed.

We are indebted to Major-General W. H. Ogilvie and Colonel R. Marnham, Consultant Surgeons, with whose encouragement this work has been continued, and to Dr. L. Doljanski, Director of the Department of Experimental Pathology, The Hebrew University, Jerusalem, for the supply of the heart extract powder there elaborated. We would also express our thanks to Colonel J. Biggam, M.C., Commanding the Hospital, for the facilities accorded, and to Major R. Walmsley, R.A.M.C., for the bacteriological studies.

## REFERENCES

- AMOROSI, C. (1931), *Rev. Pat. Sper.*, **7**, 33.  
 AREY, L. B. (1936), *Physiol. Rev.*, **16**, 327.  
 BRANDA LEONE, H., and PAPPER, E. (1941), *Ann. Surg.*, **114**, 781.  
 BUGLIARI, G. R. (1927), *Ann. ital. Chir.*, **6**, 729.

- CARNOT, B., and TERRIS, E. (1926), *C. R. Soc. Biol., Paris*, **95**, 655.
- CARREL, A. (1913), *J. exp. Med.*, **17**, 14.
- and BURROWS, M. T. (1911), *J. Amer. med. Ass.*, **56**, 32.
- DANN, L., GLUCKSMANN, A., and TANSLEY, K. (1941), *Brit. J. exp. Path.*, **22**, 70.
- DOLJANSKI, L., and HOFFMANN, R. (1939), *C. R. Soc. Biol., Paris*, **130**, 1246.
- — — and TENENBAUM, E. (1942), *Nature*, **150**, 23.
- DVORAK, H. J., and BYRAM, J. W. (1930), *Proc. Soc. exp. Biol., N. Y.*, **27**, 967.
- GREENBAUM, F. R. (1936), *Amer. J. Surg.*, **14**, 259.
- HAMMETT, F. S. (1929), *Protoplasma*, **7**, 297.
- and REIMANN, S. P. (1929), *J. exp. Med.*, **50**, 445.
- HETHERINGTON, D. C., and SHIPP, M. E. (1937), *Proc. Soc. exp. Biol., N. Y.*, **37**, 235.
- HOLDER, H. G., and MACKAY, E. M. (1939), *Ann. Surg.*, **110**, 94.
- HUEPER, W. C., ALLEN, A., RUSSELL, D. M., WOODWARD, G., and PLATT, M. (1933), *Amer. J. Cancer*, **17**, 74.
- HUNT, A. H. (1940), *Brit. J. Surg.*, **28**, 436.
- KIAER, S. (1927), *Arch. klin. Chir.*, **149**, 146.
- LUND, C. C., and CRANDON, J. H. (1941), *Ann. Surg.*, **114**, 776.
- MANDL, F., and MAYBAUM, F. (1943), *Acta medica orient.*, **2**, 136.
- MOROSOV, D. B., and STRIGANOVA, A. R. (1934), *J. Physiol. Path. gén.*, **32**, 1148.
- NAKAMURA, T. (1930), *C. R. Soc. Biol., Paris*, **104**, 191.
- NIELSEN, E. (1939), *Ugeskr. Laeg.*, **101**, 1071.
- DU NOÛY, P. L. (1916), *J. exp. Med.*, **24**, 461.
- REIMANN, S. P. (1930), *J. Amer. med. Ass.*, **94**, 1369.
- — and HAMMETT, F. S. (1929), *Proc. Soc. exp. Biol., N. Y.*, **27**, 20.
- ROBINSON, W. (1936), *Amer. Jour. Surg.*, **33**, 192.
- SCHLOSS, W. (1928), *Arch. klin. Chir.*, **151**, 701.
- SHIPP, M. E., and HETHERINGTON, D. C. (1936), *Proc. Soc. exp. Biol., N. Y.*, **35**, 180.
- WALLICH, R. (1926), *C. R. Soc. Biol., Paris*, **95**, 1480.
- WAUGH, W. G. (1940), *Brit. med. J.*, **1**, 249.
- WERNER, H., and DOLJANSKI, L. (1942), *Nature*, **150**, 660.
- YOUNG, J. S., FISHER, J. R., and YOUNG, M. (1941), *J. Path. Bact.*, **52**, 225.

## FRACTURES OF THE ZYGOMATIC TRIPOD

BY H. GORDON UNGLEY, SURGEON COMMANDER, R.N.V.R.

AND STEPHEN C. SUGGIT, SURGEON LIEUTENANT COMMANDER, R.N.V.R.

THIS paper is based upon a personal series of cases of fracture of the zygomatic tripod. Some aspects of the clinical signs and symptoms are described, and some points raised, in the radiological examination and methods of treatment of these patients. Sir Harold Gillies and his co-workers described their method of reducing the fracture via the temporal fossa in 1927, and the X-ray appearances were discussed by Graham Hodgson in 1936. A comprehensive account by Leegaard in 1939 described the canine fossa approach. A short clinical account by Nils Eckhoff appeared in 1940. McIndoe (1941), in a survey of injuries of the middle-third of the face, grouped them into two types, viz., malar maxillary (called zygomatico-maxillary in this paper) and naso-maxillary.

After treating a number of patients with fractures in this region, it was thought that some fresh points emerged, and that certain impressions were worth recording. The 14 cases here detailed have been under the care of one or other of us; in Cases 2 and 3 our two hospital ships were in company and we were, therefore, able to discuss and operate upon these 2 cases together.

In all of the cases described in this paper operations were performed either by the temporal or canine fossa approach; certain additional manipulations are also mentioned.

The anaesthesia has been inhalation in all cases, administered by means of an intratracheal tube with oral pack. Local infiltration of the canine fossa by percaine or novocain containing adrenaline was found to be a useful adjunct.

## CASE REPORTS

*Case 1.*—An R.A.F. pilot, aged 27, was landing his plane on March 13, 1940, when the retractable under-carriage jammed and he had to make a pancake landing. He sustained multiple injuries, including a fracture of the left zygomatico maxillary arch. He was concussed by the injury and on recovering consciousness complained of double vision.

No active treatment had been carried out for the facial injury at the time of the accident although an anaesthetic had been given for the reduction of a limb fracture.

On April 3 he was admitted to a hospital ship for passage to the United Kingdom and was seen by one of us (S. C. S.) for the first time.

His general condition was good but some post-concussional symptoms were still present. There was an obvious depression of the left cheek and a downward displacement of the floor of the left orbit. There was no sensory loss over the face. A severe diplopia existed which was most marked when looking downward to the left—viz., the horizontal type in which the false image overlaps the true one from above downwards.

With regard to the aetiology of this diplopia, no abnormality was detected in the nervous system, but there was ample evidence that gross mechanical disturbance of the musculature of the orbit on the left side had resulted from the lowering of the floor of the orbital cavity.

X-ray examination showed a depressed impacted fracture of the left zygomatico-maxillary arch in which the zygoma had been driven into the antrum, displaced downwards, and rotated so that the orbital surface looked forwards as well as upwards.

On April 5 an operation was performed at sea by S. C. S., exposing the fracture by the canine fossa route. The zygoma was firmly telescoped into

the cavity of the antrum and its upper surface was 4 mm. lower than the normal position. It was necessary to remove a small piece of the antral wall with the chisel before the zygoma could be disimpacted with an elevator. As the zygoma would not remain at the correct horizontal level of its own accord, after reduction, it was necessary to wire the anterior antral wall on each side of the fracture.

Following the operation the facial contour was restored and the diplopia was only present when looking at near objects or to the extreme left. He said that "objects now had a normal appearance" and that he could play cards, which was quite impossible before operation. Accommodation and full binocular vision were restored.

Radiographs showed restoration of the orbital floor, but residual separation at the articulation with the frontal bone. He was kept on soft foods following operation, and was landed in the United Kingdom on April 15, but unfortunately it has not been possible to trace him since disembarkation.

*Case 2.*—A naval rating, aged 19 years, was first seen in a hospital ship on July 21, 1940. On July 11 he had fallen over a stanchion, hitting the left side of his face. A week later he complained of pain, tenderness, and a numb feeling in the skin

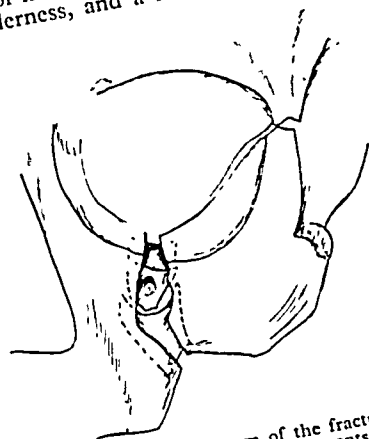


FIG. 201.—Case 2. Diagram of the fracture indicating the small bone fragments.

over the left cheek and the infra-orbital region. He was admitted to hospital ten days after the injury following an attack of epistaxis. On examination, there was a noticeable depression of the left malar eminence and a palpable depression of the left infra-orbital ridge. No diplopia or other ocular disturbance was present.

X-ray examination confirmed the presence of a depressed comminuted fracture of the left zygomatic-maxillary arch.

On July 29 an operation was performed by H. G. U. and S. C. S., exposing the fracture by the canine fossa route. A comminuted fracture of the body of the maxilla was present with depression of some smaller fragments into the antrum. The main mass, consisting of the outer part of the zygomatic arch margin and the anterior half of the zygomatic arch (viz., the whole of the zygomatic bone) was displaced downwards and posteriorly.

Two loose and completely detached bone fragments were removed and placed in saline (Fig. 201). One, measuring  $\frac{1}{4}$  in. by 1 in. on removal, exposed the soft lining of the maxillary antrum. The other, 1 in.

square, included a small portion of the infra-orbital ridge, the infra-orbital foramen, and the termination of the infra-orbital nerve. The nerve was cut short to prevent subsequent involvement in scar tissue. The main fragment was now manipulated into position by leverage with elevators, until facial symmetry was restored and the orbital floor reconstituted. In order to maintain the position of the bones, it was necessary to employ a wedge, for which purpose one of the above-mentioned bone fragments was used, and it suited admirably. The mucoperiosteum was approximated with interrupted catgut sutures. X-ray examination after the operation showed clearly the reduction of the fracture.

**POST-OPERATIVE COURSE.**—Some intermittent swelling of the face occurred in the ensuing period, and on Sept. 17 a few drops of pus, followed by some blood-stained serum, were discharged from the incision in the mouth. The facial swelling then subsided and did not recur.

On Aug. 23, twenty-five days after the operation, the patient was discharged to a naval hospital. The cosmetic effect was entirely satisfactory and the patient symptomless. One month later the fracture line was no longer evident in the radiographs. The antrum had cleared considerably, but was still slightly opaque.

On Oct. 9 he was discharged to 21 days' sick leave and thence to duty. An area of anaesthesia persisted around the infra-orbital foramen, but no discomfort or pain was present.

*Case 3.*—A naval rating, aged 38, was admitted to a hospital ship on July 26, 1940, having been hit in the left side of his face by a cricket ball two days previously. Considerable swelling and subconjunctival haemorrhage had followed, but when seen by one of us (S. C. S.) most of the bruising had subsided and a marked depression of the left side of the face in the zygomatic region was evident. A fracture line could be palpated externally and internally as a definite shelf running down the anterior wall of the maxilla from the mid-point of the infra-orbital nerve the area of skin distribution of the infra-orbital nerve there was some blunting of sensation. No diplopia was present. X rays showed a displacement of the medial part of the left zygoma downwards and

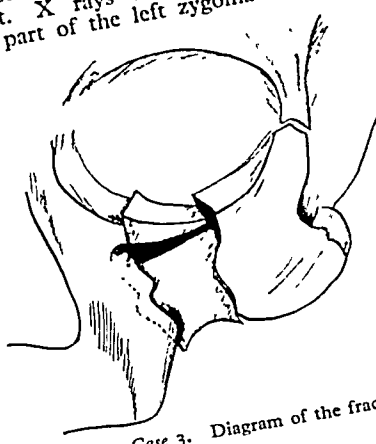


FIG. 202.—Case 3. Diagram of the fracture.

into the antrum, and slight medial displacement of the zygoma at its frontal articulation. Fig. 202, based on the X-ray photographs and on the actual operation findings, shows the fracture diagrammatically.

A second vertical fracture line was present, passing through the main mass of the zygoma, lateral and parallel to the medial fracture line. This third bone fragment was itself fractured, the small upper fragment being a portion of the infra-orbital margin (see diagram, *Fig. 202*).

On July 27 a preliminary clearance of infected teeth in the left upper alveolus was carried out.

On Aug. 6 an operation was performed by S. C. S. and H. G. U., exposing the fracture by the canine fossa approach. The medial part of the zygoma formed a fragment which had been depressed backwards and, in addition, forced medially some distance into the cavity of the antrum. At the medial vertical fracture line the fragment had gone back about 6 mm. It was elevated flush with the surface of the maxilla and with the lateral undisplaced part of the zygoma. After reduction the fragment remained firmly impacted in the correct position. Bleeding from the internal maxillary venous plexus was controlled by pressure.

X-ray examination after operation confirmed that a satisfactory reduction of the fracture had been achieved.

The paræsthesia in the infra-orbital nerve area was more pronounced than before operation, but by the time he was discharged this sensation was already returning.

The patient was discharged on Aug. 26, twenty days after the operation. Owing to movements of ships it was not possible to keep in touch with him subsequently.

region a bone elevator was passed sub-fascially downwards and medially, until the deep aspect of the fracture was reached. Elevation of the depressed malar eminence was readily accomplished, and there was no tendency of the displacement to recur. The facial contour was restored and X-ray examination confirmed the reduction (*Fig. 204*).

The slight post-operative swelling subsided in a few days and he returned to duty on Feb. 12.

*Case 5.*—An able seaman, aged 29 years, was admitted to a hospital ship on Feb. 5, 1941, with the history that on Feb. 4, while hoisting the motor-boat inboard, he was dragged round the winch drum by his right arm getting caught up in the fall, his face being brought up forcibly against the edge of the drum.

On admission, twelve hours later, he was extremely collapsed from shock and loss of blood. There was a compound fracture of the right side of the face with a laceration extending from the medial canthus of the right eye down the side of the nose and lateral to the angle of the mouth, ending over the body of the mandible.

In addition there were fractures of ribs, and of the right upper extremity. After blood transfusion and other resuscitatory measures he was submitted to operation, at which the following facial injuries were found: (a) A compound fracture of the frontal bone into the right frontal sinus. (b) A compound



*FIG. 203.*—*Case 4.* Before operation, mento-nasal view showing a depressed fracture of the left zygoma into the maxilla and increased density of the maxillary antrum.



*FIG. 204.*—*Case 4.* After operation, mento-nasal view showing reduction of the fracture.

*Case 4.*—An able seaman, aged 41 years, sustained an injury to the left side of the face from a fist blow on Feb. 2, 1941, and was admitted to a hospital ship on Feb. 3. An obvious depression of the left zygomatico-maxillary arch was present, and was confirmed by radiography (*Fig. 203*). There was no diplopia.

An operation was performed by H. G. U. on Feb. 4. Through a small skin incision in the temporal

fracture of the right maxilla involving the medial side of the floor of the orbit and the maxillary antrum, and a simple fracture of the right zygomatico-temporal arch. The fragment of bone between these fractures, consisting of the zygoma and the greater part of the maxilla, was displaced laterally and slightly backwards, carrying the orbital contents with it. This lateral displacement of the eye and the cheek produced a most hideous deformity.



The eyeball was intact, although it was displaced outwards and downwards, and the eyelids were closed with œdema and ecchymosis. The lachrymal duct, was torn across at the medial canthus in the line of the deep lacerated wound. There was also a fracture of the neck of the right condyle of the mandible.

Operation by H. G. U. on Feb. 4. An excision of the wound was performed as far as the conditions permitted, for grease was ingrained into the tissues and comminution of the bone into splinters had occurred.

The malar eminence, together with approximately the lateral two-thirds of the orbital floor and a great part of the anterior wall of the maxillary antrum, was freely mobile, and was readily reduced by firm pressure with the padded thumbs from below and laterally. By this manoeuvre, too, the orbital floor was restored to its normal level. In order to prevent the immediate re-displacement, which occurred when the pressure was released, it was necessary to insert a wire loop between the maxilla and the nasal bone. This wiring procedure proved quite satisfactory in maintaining the position of the fragments.

He made good progress from the operation in both local and general condition. As the œdema of the eye absorbed he regained full vision without diplopia.

On March 30 the operation wound was soundly healed, except at the upper end where the lacrimal duct had been torn. At this point superficial sepsis occurred from constant watering of the eye, and finally, when part healed some contracture of the fibrous tissue took place, resulting in a confusion diplopia.

The patient was recommended to attend a plastic unit on account of soft-tissue scarring around the medial canthus and down the face. He refused further treatment, however, and returned to his home in Skye on June 18, after being invalided from the Service.

*Case 6.*—A naval rating, aged 47, was admitted to a hospital ship on Sept. 14, 1941. He had been struck by a fist on the left side of the face three days previously.

On examination he had a black eye, with a slight degree of subcutaneous emphysema of the upper part of the left cheek. There was submucous extravasation of blood in the left buccal region. On looking at the patient from in front and from the left side there was an obvious depression of the zygoma in spite of the bruising which tended to mask it. A depression of the orbital margin could be felt distinctly and pressure in this area gave rise to pain in the distribution of the infra-orbital nerve. There was a feeling of numbness in this region, but the sensory loss was only partial. There was no diplopia. The upper jaw was edentulous.

X rays showed that the left zygoma was completely separated from its attachments and driven downwards and medially into the left antrum, with comminution of the anterior antral wall. The zygoma was also rotated on its long axis so that the orbital surface tended to look forwards as well as upwards.

On Sept. 14, the day of admission, he was operated upon by S. C. S., the fracture being exposed by the canine fossa approach. The anterior antral wall was found to be hopelessly comminuted, and after removing the loose fragments no piece large enough to act as a splint graft (as in *Case 2*) was available. The zygoma was quite mobile and could be pushed back into its proper relationship at the frontal and temporal attachments by a finger in the antral cavity. A graft

was removed from the left 8th costal cartilage and was fitted across the deficiency in the anterior antral wall, being sutured in position with stout catgut through drill holes on each side.

The black eye and subcutaneous emphysema cleared up, and radiographs on Sept. 16 showed the zygoma to be in good position.

On Oct. 2 he was sent away on 14 days' sick leave, but just as he was due to return he developed an ischio-rectal abscess and was admitted to another hospital. The patient stated that a facepiece was strapped tightly over his face during the induction of anaesthesia. A week later he got a bad cold. On Nov. 27 he returned to the hospital ship. The zygoma had completely collapsed into the pre-operative position and he said that for the last three weeks the left side of his nose had been completely blocked. On examination several large polypi were seen in the nasal meatus. These were not present when he went on leave, and at that time there was no evidence of nasal infection. He also complained of an excessive amount of light entering his left eye from the outer side.

On Nov. 28 the nasal polypi were cleared and the left canine fossa reopened. Pus was present in the antrum. The graft was removed from the floor of the antrum, and an intranasal antrostomy opening made. A piece of dental composition was moulded along the floor of the antrum in order to keep the fracture line as widely open as possible. The mucosa of the canine fossa was left unsutured to allow free drainage.

In the immediate post-operative period there was a fair degree of reactionary swelling of the left cheek,



FIG. 205.—*Case 6.* After second reduction, showing the wiring of the zygomatico-frontal articulation and the wire strut across the deficiency in the anterior antral wall.

but this responded rapidly to sulphanilamide (culture of pus grew streptococci).

On Dec. 4 the infection of the nose and antrum had subsided and under intratracheal anaesthesia the canine fossa was again opened and the dental composition removed. An incision was made along the lateral

orbital margin and the articulation of the zygoma with the frontal bone exposed. A double fracture line was present, enclosing a small fragment. Holes were drilled, and the zygomatico-frontal articulation was wired with 28 S.W.G. silver wire and the incision closed. Returning to the canine fossa the maxilla

not eat a crust without discomfort as "there did not seem to be enough room in the mouth".

On examination an obvious depression of the left malar eminence represented the facial deformity of which the patient complained. There was a small puncture wound of the left cheek surrounded by an



FIG. 206.—Case 7. Photographs of the patient showing the deformity which may result from a depressed fracture of the zygomatico-maxillary arch (left).

and zygoma were drilled and a double strand of 27 S.W.G. silver wire was threaded across the deficiency in the anterior antral wall, to act as a strut and thereby prevent redisplacement. The canine fossa mucosa was closed. Full doses of sulphanilamide were given over the next two days.

Dec. 8: X rays showed a great improvement (Fig. 205). Clinically the facial contour was restored. Henceforth convalescence was uneventful.

Dec. 28: X rays showed that the position of the zygomatico-maxillary arch was maintained, and indicated for the first time that in addition to the separation at the synostosis of the zygomatico-temporal arch there was a fracture line through the zygomatic process of the temporal bone.

On Jan. 1, 1942, the canine fossa was soundly healed and he was able to wear his new dentures. On Jan. 5 the patient was evacuated to a Royal Naval hospital ashore, whence he returned to duty. A letter was received from him at the end of March, 1942, to say that apart from numbness of the lip he was quite fit and well. Some comments on the employment of cartilage grafts in this type of case, and the value of zygomatico-frontal wiring, are made in a later section of this paper.

*Case 7.*—An able seaman, aged 35 years, sustained multiple injuries on Jan. 9, 1942, when he fell down the coal chute while on duty on board ship. There was a fracture-dislocation of the left shoulder and an injury to the left side of the face.

He was seen for the first time by one of us (H. G. U.) ten days after the injury. The shoulder had been adequately treated, but a depressed fracture of the left zygomatico-maxillary arch had not been dealt with.

The patient complained of facial deformity, headache, and attacks of dizziness. He stated that there was some difficulty in chewing, e.g., he could

area of chronic cellulitis, 2 in. square, which was indurated and slightly tender. Both these features, as well as the depression of the lower orbital margin



FIG. 207.—Case 7. Mento-nasal view showing a depressed and comminuted fracture of the left zygomatico-maxillary arch.

on the same side, are clearly shown in the photographs of the patient (Fig. 206).

The fracture line was easily palpable in the lower orbital margin and in the zygomatico-temporal arch.

There was some demonstrable infra-orbital anaesthesia. No diplopia was present. X-ray examination

(Fig. 207) showed a depressed and comminuted fracture of the left zygomatico-maxillary arch. The orbital floor and the infra-orbital margin particularly were badly splintered and the lateral half of the floor was rotated and displaced downwards.

The density of the maxillary antrum and the wide separation of the fractured surfaces here were clearly shown.

The fracture of the zygomatico-temporal arch was also seen.

On account of the inflammatory reaction in the left cheek, it was decided to attempt reduction of both fractures via the temporal route, instead of operating via the canine fossa approach.

A bone elevator was passed through a small left temporal incision subfascially towards the fracture.

The zygomatico-temporal arch was readily elevated, but the zygomatico-maxillary fracture was found to be fixed, and could not be disimpacted by this route.

Owing to unavoidable circumstances, this patient was discharged before the second operation, via the canine fossa route, which was planned to take place as soon as the cellulitis of the cheek had subsided.

This case is recorded because it represents one of those where the best avenue of approach was denied to the surgeon at the outset on account of inflammation in the path of the operative approach in the cheek. No case could demonstrate more convincingly the unsightly deformity which results from an unreduced depressed fracture of the zygomatico-maxillary arch.

*Case 8.*—A marine, aged 20 years, fainted and fell when on parade on July 26, 1941, and was admitted to hospital two hours later with an injury to the left side of the face.

There was a small abrasion of the left cheek and a depression of the left malar eminence. A palpable fracture line in the lower margin of the left orbit was present and some conjunctival hæmorrhage was visible.

It was not thought at the time that the deformity was of sufficient magnitude to warrant an operation for its cure. Radiographs of the types portrayed in this paper were not taken and no adequate radiological record is obtainable.

He was returned to duty 24 days after the injury.

On April 11, 1942, he was admitted to hospital on account of persistent pain "like toothache" around the left eye, most marked in the infra-orbital region, and worse after food. It was at this stage he was first seen by one of us (H. G. U.).

A slight depression of the left malar eminence and a prominent spicule of bone along the left infra-orbital margin remained as clinical evidence of the old fracture.

No objective change in the sensory area supplied by the infra-orbital nerve was demonstrable. The cranial nerves were normal except that the left eye returned to the central position in a few seconds when the patient was looking downwards and to the left.

X-ray examination revealed an old soundly united fracture of the zygomatico-maxillary arch. No operative interference to the fracture was deemed advisable at this stage.

This case is of interest as an example of a late sequela which occurs from time to time in these fractures.

From clinical experience in our small series, we feel that any depressed fracture of the zygomatico-maxillary arch is worthy of an operative reduction at the time of injury, not merely to restore facial appearance, but to reduce the chance of late neuralgic pains in the infra-orbital nerve.

*Case 9.*—A dockyard labourer, aged 24 years, received the following injuries on March 21, 1942, as the result of a spar falling upon his head:—

a. Fracture of the base of the skull involving the right petrous bone. Bleeding from the right ear and paralysis of the right sixth and seventh cranial nerves were also noted.

b. Cerebral concussion and clinical signs of irritation of the motor area of the right cerebral cortex.

c. Fracture of the bridge of the nose with deviation to the left side.

d. At a later date, when the skull was X-rayed, a fracture of the right zygomatico-maxillary arch was discovered.

This patient was first seen by S. C. S. on June 4, some eleven weeks after the injury. Complete Sixth and Seventh cranial nerve paralyses with chorda tympani loss were still present. (These nerves later recovered their function.)

Bilateral chronic suppurative otitis media had existed for many months prior to the accident. Clinically there was no backward displacement of the right zygomatic bone, but a moderate lowering of the lateral part of the lower margin of the right orbit could be made out when compared with the opposite side. X rays showed a wide separation of the frontal and temporal articulations, with an additional fracture of the zygomatic process of the temporal bone, posterior to its articulation with the zygoma. There did not appear to be much displacement at the fracture line running through the lateral part of the antrum.

The extent of the displacement is much greater than the clinical appearance suggested. The explanation appeared to be that the fracture was caused by a blow from above. The zygomatico-maxillary arch thus escaped the usual backward and medial displacement associated with force applied from the front and outer side, and only a downward displacement of the outer end of the arch occurred. Diplopia was slight and intermittent, and cleared up with the recovery of the sixth nerve paralysis.

In the absence of diplopia and depression of the facial contour, it was not considered necessary to interfere. Moreover, there was a risk of transmitting movement to the fracture in the petrous temporal bone, which lay in close proximity to a suppurating middle ear.

*Case 10.*—A naval rating, aged 49, was struck on the face in a brawl on April 6, 1942. There was considerable bruising of the face and he was taken to the nearby hospital, where he was first suspected of having an intracranial injury. Subsequently on X-ray examination he was found to have a fracture of the left zygomatico-maxillary arch, with an opacity of the left antrum due to hæmorrhage into it. After three weeks in hospital and two weeks' sick leave he returned to his Base.

On account of visual disturbances and nasal obstruction he was referred to a naval hospital, where he was seen by one of us (S. C. S.) on June 11. On clinical examination one could easily detect a moderate degree of depression of the left zygomatico-maxillary arch. Diplopia, in which one image was superimposed above the other, was present in the left half of the visual field and was increased on looking to the left. No infra-orbital anæsthesia was present.

X-ray examination on June 12 (Fig. 208) showed a characteristic displacement downwards, posteriorly, and medially of the left zygomatico-maxillary arch. A special view, taken in the position previously suggested to us by Dr. Graham Hodgson in a personal

communication, showed an absence of comminution of the anterior wall of the antrum.

On June 13, thirty-seven days after the injury, an operation was carried out by S. C. S. In spite of the absence of comminution, it was decided to attempt reduction of the fracture by the canine fossa route

On June 29 a submucous resection of the nasal septum was carried out under local anæsthesia in order to relieve a right-sided nasal obstruction resulting from traumatic deflection of the septum. He was discharged to sick leave and duty on Aug. 4.

*Case 11.*—A V.A.D., aged 23, fell off her bicycle on Aug. 20, 1942, striking the left side of her face against the ground. She was seen on the roadside by S. C. S. within an hour of the injury.

There was characteristic flattening of the left malar eminence with a palpable fracture line in the left infra-orbital margin. Left-sided epistaxis was present and anæsthesia in the distribution of the left infra-orbital nerve had already developed. There was no lowering of the orbital floor and no diplopia.

The mento-nasal X-ray picture showed an opaque left antrum and a fracture line in the anterior antral wall running downwards from the infra-orbital margin. There was only slight separation of the frontal and temporal articulations, and no downward displacement of the zygoma as a whole. A view taken in the position suggested to us by Dr. Graham



FIG. 208.—*Case 10.* Before operation, mento-nasal view showing displacement of whole zygoma posteriorly and medially, with separation at the frontal and temporal articulations (see arrows).

owing to the long interval that had elapsed since the injury. The frontal articulation was first exposed by an incision along the lateral orbital margin, and the bones were cleared of soft tissues. The bone ends were then drilled and stainless steel wire was threaded through, but not tightened. The maxillary fracture line was then exposed through an incision in the mucous membrane of the canine fossa. The zygoma which had been driven into the maxillary antrum, was disimpacted by gripping it with lion forceps. This was accomplished more easily than expected. Apart from one or two cracks in the antral wall, there was no comminution. While the zygomatico-maxillary arch was pushed up from the canine fossa below, the wire through the adjacent bone ends at the frontal articulation was tightened.

This manoeuvre provided considerable fixation and was extremely valuable, as it also gave a hinge which enabled one to wedge the fracture in the anterior antral wall with a small piece of bone removed from the area where the bone was thin.

This additional elevation of the zygoma completed the restoration of the facial contour. Wiring of the fracture in the anterior wall of the antrum would not have been possible as the bone was very thin there.

The post-operative course was uneventful apart from some swelling of the upper eyelid, which passed off in 24 hours. The diplopia disappeared completely. Radiographs on June 16 showed the zygomatico-maxillary arch to be in correct position. The restoration of the contour at the zygomatico-temporal articulation was striking.



FIG. 209.—*Case 11.* Graham Hodgson view (from below and behind) of the fracture line in the anterior antral wall, showing the absence of comminution (left side).

Hodgson (*Fig. 209*) showed a clear-cut fracture line without comminution of the anterior antral wall. Operation was carried out by S. C. S. six hours after injury at a W.R.N.S. Sick Quarters under general anæsthesia. It was interesting to see how in the interval that had elapsed the soft-tissue swelling of the cheek had now masked the depression of the malar eminence. If at this stage she had been seen for the first time, it would have been hard to persuade a sceptic that reduction was necessary, particularly as

the mento-nasal X-ray picture did not show the displacement. The displacement of the zygoma was entirely backwards. This case was ideal for reduction by the temporal route, which was performed forthwith. The depressed zygoma came forwards easily with a click, and remained securely in the corrected position. Convalescence was uneventful.



FIG. 210.—Case 12. Less common type of case, showing two vertical fractures in the left zygomatico-maxillary arch (see arrows) without displacement. Fracture of the zygomatico-temporal arch is also seen.

*Case 12.*—An aircraftsman, aged 39, was involved in a bicycle accident on Aug. 28, 1942, and was admitted to hospital 24 hours afterwards. There was a severe subconjunctival hæmorrhage in the left eye and ecchymosis of the eyelids. The left cheek was tender in its lateral part and there was anæsthesia in the distribution of the left infra-orbital nerve. There had been slight left-sided epistaxis. (We are indebted to Surgeon Commander J. Johnston, R.N., for these notes.)

Radiographs (*Fig. 210*) show two vertical fracture lines, one passing down the anterior antral wall and involving the infra-orbital foramen, and the other, more laterally, passing down through the body of the zygoma. This type of fracture results when the blow strikes directly from in front. Fracture of the zygomatico-temporal arch is also seen. No displacement of the fragments is apparent. The Graham Hodgson view showed no comminution of the fracture line in the anterior antral wall.

The patient was seen on Sept. 8, eleven days after the accident, by S. C. S. Clinically there was no depression of the cheek at all, nor was diplopia present. Infra-orbital anæsthesia was still evident, but the subconjunctival hæmorrhage had begun to clear. It was agreed that there was no clinical or X-ray evidence of deformity of the zygomatico-maxillary arch and that no operative interference was indicated. On Sept. 11, fourteen days after the injury, infra-orbital sensation had completely returned.

*Case 13.*—A Marine, aged 38 years, was hit in the face by the bare fist of a messmate while at lunch at

13.15 hr. on Sept 9, 1942. He was admitted to a naval hospital the same day and was seen by H. G. U.



FIG. 211.—Case 13. Comminuted fracture on the right side with gross displacement of the zygoma postero-medially, but without any appreciable lowering of the orbital floor (hence no diplopia).

Bleeding from the right side of the nose had occurred immediately after the accident, and was present to a slight extent on admission. There had been no loss of consciousness.

Examination on admission showed that there was a marked depression of the right malar eminence, and a palpable fracture line in the middle of the lower orbital margin. A slight oozing of blood was apparent in the right nostril. Neither infra-orbital anæsthesia nor diplopia was present. There was a lot of œdema and discoloration of the right eye.

X-ray examination (*Fig. 211*) revealed a depressed and comminuted fracture affecting mainly the body of the right zygomatic bone, which was displaced in a postero-medial direction. On account of the recent nature of the injury it was thought feasible to try reduction by the temporal approach.

Accordingly at 19.00 on Sept. 9 an operation was carried out by H. G. U. A bone elevator was passed via the temporal fossa to the site of the fracture. This attempt failed to elevate the depressed bone. A second operation was performed by H. G. U. on Sept. 17, the fracture being approached this time via the canine fossa route. After disimpacting the fracture, elevation was successfully accomplished and the bones maintained their position by interlocking of the fragments. X-ray examination (*Fig. 212*) showed that the restoration to normal position had been obtained.

In two or three days, when the swelling had subsided, it was apparent that the deformity had been fully reduced. His subsequent course was uneventful.

*Case 14.*—A cadet, aged 17 years, fell on the ball while playing rugger on Nov. 2, 1942. Another boy fell on top of him, striking the right side of the patient's



FIG. 212.—*Case 13.* After reduction, showing re-alignment and the improved translucency in upper lateral part of the maxillary antrum where impaction had previously obscured it.



FIG. 213.—*Case 14.* Displacement of the right zygoma with wide separation at the zygomatico-frontal articulation and lowering of the floor of the orbit. (Diplopia present.)

face with his knee. A right-sided epistaxis was present for a few hours after the injury.

He was first seen by S. C. S. on Nov. 6 on account of facial deformity. There was gross depression of the right malar eminence and a palpable fracture line in the anterior antral wall. A subconjunctival hæmorrhage at the outer canthus of the right eye and subsiding ecchymosis of the eyelids were still in evidence. Diplopia with one image above the other had been noticed since the injury and was found to be localized to the right half of the visual field. A complete infra-orbital anæsthesia existed.

The antero-posterior radiograph (*Fig. 213*) showed gross displacement of the right zygoma including a lowering of the lateral orbital floor and wide separation at the frontal articulation. The frontal process of the zygoma lay medial to and below the zygomatic process of the frontal bone. In both the anteroposterior and the special Graham Hodgson views tessellation of the anterior antral wall was plainly discernable.

On Nov. 9, that is, one week after the injury, an operation was carried out by S. C. S. The frontal articulation of the zygoma was first exposed. The bone ends were drilled and threaded with 0.6 mm. stainless steel wire. The main fracture line was then exposed via the canine fossa approach. Four large bone fragments were detected, of which three were removed after the fracture had been disimpacted. The fourth piece had a good soft-tissue attachment and was replaced after blood-clot had been evacuated from the antrum.

The wire at the zygomatico-frontal articulation was now tightened and at the same time the zygoma was pushed up from the canine fossa.

The reduction was complete and was maintained by the wire. The replaced bone fragment of the anterior antral wall was in no way a strut in this case, all the strain being borne at the frontal articulation. Facial contour was restored and the diplopia completely corrected.



FIG. 214.—*Case 14.* After reduction, with wiring at frontal articulation. Arrows indicate the sites of the fracture lines

X-ray examination confirmed the reduction; the radiograph is shown in *Fig. 214*.

Sensation in the infra-orbital nerve area began to return nine days after the reduction.

## DIAGNOSIS

### Clinical Features.—

**Facial Deformity.**—The most characteristic feature of these cases is a flattening of the facial contour (Fig. 206), which is usually discernible even where bruising and swelling of the face are present. This deformity is always seen best when the patient is viewed from the side.

**Palpable Fracture Line.**—In all our cases it was particularly easy to palpate the fracture along the orbital margin.

**Infra-orbital Nerve Injury.**—A varying degree of anaesthesia or pain in the distribution of the infra-orbital nerve is frequently present and is additional evidence of the site of bone injury. It is mentioned by Eckhoff (1940), and was present in all Leegaard's cases (1939) and in 9 out of 10 cases quoted by Ivy and Curtis (1938). In the present series 7 out of 14 showed this feature.

**Diplopia.**—This disturbing sequel of zygomatico-maxillary fractures was present in Cases 1, 10, and 14 of our series. It is quoted by Eckhoff (1940) and it occurred in 3 out of 10 cases in the series recorded by Ivy and Curtis (1938). Leegaard (1939) did not mention it in his contribution to the subject.

In Case 9 diplopia was intermittent and cleared up with the recovery of the concomitant sixth-nerve paralysis, which had resulted from the middle fossa injury in the petrous bone. Although considerable downward displacement of the zygoma had occurred no diplopia appeared to result from this. It may be that *backward* as well as downward displacement of the orbital floor is necessary in order to produce diplopia.

**Hæmorrhage into the Maxillary Antrum.**—This appears to be a frequent concomitant, but does not as far as we have found give rise to any untoward symptoms or complications unless there is pre-existing infection in that site. Incidentally this hæmorrhage provides additional evidence of the fracture in the X-ray picture.

**Unilateral Epistaxis.**—This sign is mentioned by Sir Harold Gillies (1927). It occurred in 6 of our 14 cases.

**Surgical Emphysema of the Face.**—This occasionally occurs if the fracture line passes through the nasal mucosa. It is mentioned by Eckhoff (1940) and occurred in our sixth case, which also had a small subconjunctival hæmorrhage on the homolateral side.

**Difficulty in Closing the Jaw.**—This has been described by Ivy and Curtis (1938), and was present in 4 out of 10 of their cases, but in our experience this is an unusual feature. It was present to a slight extent in Case 7 of our series, and in Case 5, where a fracture of the mandible had also occurred.

**Radiographic Features.**—We have found that the most useful view is the mento-nasal such as is used to demonstrate the maxillary antra. This

gives a good general idea of the displacement of the zygoma in relation to the other bones of the face.

The main points to note are as follows:—  
1. *In the region of the maxillary antrum:*  
a. The degree of comminution of the anterior wall of the antrum. It is of value to know the amount of comminution of the anterior wall of the maxillary antrum. The usual views do not give much help in this respect. Recently Dr. Graham Hodgson suggested to us an X-ray position which gives some indication of the degree of this comminution. The head is put in the occipito-mental position, i.e., the chin resting against the Potter Bucky, and the orbital-mental line at an angle of 45° to the horizontal, this angle being open towards the feet with the patient in the erect posture. The head is then tilted over towards the opposite or intact side; at the same time the face is slightly rotated towards the intact side, approximately 10° to 15°. Fig. 209 is a radiograph taken according to this technique, but with a varying degree of tilt of the head. The fractures are shown as clear-cut lines. In Case 10, where the fracture was exposed at operation, the absence of comminution demonstrated by this particular X-ray view was directly confirmed.

b. The degree of impaction and telescoping of the zygoma into the cavity of the antrum.

c. The associated opacity of the antrum. There is always some opacity of the maxillary antrum on the side of the injury. This does not necessarily indicate hæmorrhage into the antral cavity as it can be produced by œdema of the lining mucosa, which always occurs to a greater or lesser degree. The presence of a fluid level is positive evidence of blood in the cavity.

2. *The separation and/or fracture in the vicinity of the zygomatico-frontal synostosis.* Separation of the synostosis between the zygomatic and the frontal bones is common and may be the only sign according to Graham Hodgson (1936). It is well shown in Case 10 (Fig. 208) and occurred in 50 per cent of this series. He (Graham Hodgson) is also of the opinion that separation usually occurs without fracture, which accords with our experience. In Case 6, where fracture occurred on the zygomatic side of the junction, the degree of violence was much greater than in the other cases.

In Case 9 the degree of fracture and displacement of this part of the facial structure was great, and to a large extent the direction of the blow was from above, as was shown by the concomitant fracture of the petrous temporal.

3. *The separation and/or fracture in the vicinity of the zygomatico-temporal synostosis.* Separation at the zygomatico-temporal suture, or fracture on either side of it, increases the mobility of the zygoma. It occurred in 5 out of the present series of 14 cases and is seen particularly well in Cases 9 and 13.

**Characteristics of the Fracture.**—Fractures of the zygomatico-maxillary arch result from direct injury, but the characters of the fracture vary according to the direction and site of the blow. These fractures may be classified as follows :—

1. *Blows from the Front.*—This type of trauma results in a double vertical fracture line—one through the anterior antral wall, the other lateral and parallel through the body of the zygoma. The intervening block of bone is forced directly backwards, "avec absence d'enforcement dans le sinus comme dans le groupe suivant" (Le Fort, 1901). Case 3 belongs to this group. Case 12 is a latent example of this type. The two vertical fracture lines are present, but no posterior displacement of the intervening bone has occurred.

2. *Blows from the Antero-lateral Aspect.*—This is the more common variety and results in the zygoma as a whole being driven posteriorly and medially into the antrum, the fracture line passing through the weakest point, that is, in the region of the infra-orbital foramen and extending vertically downwards from this point.

In this 'telescopic' variety of fracture, there is often comminution of the maxilla (usually the anterior wall of the antrum) and of the zygoma. On the other hand, the zygoma as a whole may be rotated medially and in a horizontal plane, so that the orbital surface looks forwards and slightly to the nasal side.

Separation of the synostosis between the zygomatic and frontal, and/or between the zygomatic and temporal, bones is common in this group of injuries. Fractures alongside the synostoses occur less often and indicate greater violence.

3. *Blows from the Nasal or Antero-medial Aspect.*—In this variety of injury the antero-lateral portion of the maxilla, together with the zygoma, is forced backwards and laterally, carrying a large part of the orbital floor and infra-orbital margin in the same direction.

Comminution was very extensive in the one case of this type that we have been able to record (Case 5). Such was the mobility of the detached fragment that fixation by wire passed between the maxilla and the lateral nasal bone was necessary in order to maintain reduction.

### TREATMENT

Leegaard (1939) has stated that expectant treatment is to be condemned, an opinion endorsed by all who have had experience in the treatment of these injuries. Evidence to convince the most sceptical is contained in his paper, wherein an untreated case is portrayed. Also a contribution by Eckhoff (1940) gives a vivid impression of the deformity that may result from inadequate treatment.

**The Importance of Early Diagnosis and Treatment.**—The advantage of prompt surgical intervention is exemplified in two cases of our

present series. Our first case was operated upon twenty-five days after his injuries and considerable force was required to disimpact the zygoma. In striking contrast, there was the degree of mobility of the zygoma in Case 6, which was submitted to operation only three days after the fracture had been sustained. Nevertheless, we consider that these fractures can still be reduced, even when a long period has elapsed since the injury, and that, if obvious deformity or diplopia are present, operation should always be attempted.

In this connexion Case 10 is interesting in that even thirty-six days after the injury it was possible to move the malar eminence by pressure on the outside of the cheek, and the patient volunteered the information that the diplopia decreased so long as pressure was maintained. This case was successfully treated by operation thirty-seven days after the injury.

**Methods.**—The following methods of treatment will be considered: (1) Reduction of the fracture via the temporal route; (2) Exposure and reduction of the fracture through the canine fossa route.

*Elevation by the Temporal Route:* The method of passing an elevator through a small skin incision within the hair line of the temporal fossa, along the temporal muscle to the site of the fracture in the zygomatico-maxillary arch, was described by Sir Harold Gillies in 1927. It has the advantage of being a clean approach through an area removed from the actual site of injury. It is found, however, that some cases are not reducible by this method, or if the fragments are replaced they will not remain in position after the elevating force is removed, owing to comminution of the bones at the site of the fracture, particularly of the anterior wall of the maxillary antrum.

The X-ray position suggested to us by Dr. Graham Hodgson (1936), and described above, is a valuable help in demonstrating the presence or absence of comminution of the anterior antral wall. This information, combined with clinical examination, usually suffices to indicate whether this temporal approach is worthy of a trial.

If a long period has elapsed between the injury and the time the patient is brought to operation then this method is not suitable owing to the force necessary to disimpact the fragments, and the probability of some form of fixation being required.

*The Canine Fossa Approach.*—This method of exposing the fracture is described by Leegaard (1939). Intratracheal anaesthesia with the throat packed off, together with local infiltration of the mucoperiosteum in the canine fossa with pericaine or novocain containing adrenaline, are the prerequisites of a successful operation.

A horizontal incision down to the bone is made above the tooth sockets in the canine fossa of the maxilla. With a periosteal separator the mucoperiosteum is reflected on each side of the incision but particularly on the upper side. Full retraction of the edges of the wound (for which purpose



a mastoid retractor or Hajek's retractors are useful), together with complete hæmostasis, enable a clear view of the fracture to be obtained.

Disimpaction, reduction, and fixation of the fracture can now be embarked upon. It is sometimes possible to attain reduction simply by means of a bone elevator passed between the fractured surfaces. In some cases disimpaction can only be achieved by removing bone fragments, after which the depressed bone can be restored to its normal position by traction with lion forceps. The various manœuvres for fixation are outlined below. It is well to bear in mind the proximity of the infra-orbital foramen, with its issuing nerve.

The internal maxillary venous plexus is sometimes the source of troublesome bleeding, which may require prolonged pressure or a muscle-graft to check it. The operation is completed by suturing the mucoperiosteum with interrupted catgut series.

This approach has the advantage that the fracture is exposed to view and however great the deformity, impaction, and comminution, reduction of the fragments can be achieved and maintained. This method has the disadvantage of exposing the fracture through a potentially infected oral cavity, and it is necessary to delay operation if dental sepsis is present. Infection of the antrum has occurred in only one of the present series (Case 6). In this instance, a cartilage-graft had been inserted, but infection of the antrum arose four weeks after reduction of the fracture, following upon an operation for an ischio-rectal abscess which was opened under inhalation anaesthesia. A second reduction and fixation by wiring was carried out after drainage of the antrum by an intranasal antrostomy. Intranasal antrostomy has not been found necessary in any of our other cases.

**Methods of Maintaining Reduction.**—In cases where extensive comminution allows the fragments to fall back after reduction, it is necessary to apply some method of fixation, and it is in these cases that the canine fossa route is particularly useful.

Sir Harold Gillies (1927) suggests as an additional help the wiring of the external angular process, and Eckhoff (1940) the wiring of the frontal articulation.

1. *Fixation at the Zygomatico-temporal Articulation:* This has not been carried out in any case in this series, but it would have been advisable in Case 9 if reduction had been deemed necessary, as the displacement was greatest at this point.

2. *Fixation at the Zygomatico-frontal Articulation:* There are two main indications for this procedure: first, diplopia with wide separation of the synostosis between the zygomatic and frontal bones; and secondly, a large deficiency of the anterior antral wall following extensive comminution.

Where this fixation is considered necessary the operation takes the form of wiring (using soft round malleable stainless steel wire) at the

zygomatico-frontal synostosis, combined with exploration of the fracture line by the canine fossa. In Cases 6, 10, and 14 it was striking to see the good fixation obtained when the zygoma was pushed up from the canine fossa below, and the wire at the zygomatico-frontal articulation was tightened, even though there was incomplete fixation at the fracture line in the anterior antral wall.

Even where there is a considerable bony loss of the anterior antral wall, we have found that a combination of fixation at the zygomatico-frontal suture together with bone-wedging or the use of a wire strut across the gap has proved adequate in maintaining the reduction of the fragments. The use of a bone-graft has not been found necessary in any of the present series of cases.

The result would have been improved if fixation had been carried out in Case 1. In Case 6 it was necessary to fix a zygoma that had been separated at all its points of attachment. In the above-mentioned cases there was immediate and complete loss of the diplopia.

3. *Fixation at the Fracture Line in the Anterior Antral Wall:* Three methods have been used in this case series: simple impaction, wedging with one of the loose bone fragments, and wiring. Cases 3, 4, 11, and 13 were the ones in our series in which simple impaction of the bone fragments was sufficient to maintain the corrected position. Wedging with a bone fragment obtained from the fracture line was highly successful in Case 2, and was also used in Case 10, together with wiring at the zygomatico-frontal synostosis. Wiring was used in Cases 1, 5, and 6. Even in the absence of comminution, wiring is often difficult owing to the fragility of the anterior antral wall, but this method is quite satisfactory.

4. *External Fixation:* Aleman, quoted by Leegaard (1939), used a plaster cap with a metal arm. A screw is passed through the skin of the cheek into the body of the zygoma. After reducing the fracture the screw is fastened to the metal arm by an elastic band. Similarly a wire loop passing under the depressed fragment of bone and out through the soft tissues of the cheek may be suspended from a rigid bar incorporated in the plaster head cap.

Matas, quoted by Ivy and Curtis (1938), described in 1896 a method in which "a heavy curved needle is passed from above downwards through the skin beneath the depressed fragment to emerge below the arch. The needle is threaded with heavy silk, which in turn serves as a carrier for a piece of silver wire. The two ends are twisted together and afford a means of traction on the bone fragment whereby it is elevated into position. In case of tendency to recurrence, the wire is twisted over an ordinary glass microscopic slide whose ends rest on the firm portions of the bone."

We have not used external fixation in any of our cases.

*The Difficult Case.*—Cases 6 and 7 represent our two most difficult problems. In the former the method of fixation used at the first operation was wrong. Cartilage should not have been used as a graft, as it has a tendency to soften and undergo absorption before the displaced bone has fully consolidated, and the fixation at the zygomatico-frontal articulation by wiring should have been carried out at the first operation.

In Case 7 the better approach was clearly via the canine fossa on account of the comminuted and impacted fracture of the zygomatico-maxillary arch of two weeks' duration. This route was not used at the first operation owing to the cellulitis of the cheek which rendered unsafe a dissection in this area.

### PROGNOSIS

**a. Deformity.**—It is well to remember that even in cases of untreated fractures of the zygomatico-maxillary arch where the deformity is slight after the injury, the disfigurement tends to become more, rather than less, pronounced with the passage of time, owing to the fibrotic contraction of the tissues of the face into the depressed bone. Kilner (1942) deals with these cases of established deformity by the insertion of fat grafts into the soft tissues of the cheek. In some cases it may be necessary to build up the depression by the insertion of bone or cartilage grafts.

**b. Injury to the Infra-orbital Nerve.**—Even after a successful reduction of a fracture, anaesthesia in the distribution of the infra-orbital nerve may exist for a long period. Infra-orbital neuralgia is an unpleasant sequel that may occur more particularly in those cases where a reduction of a depressed fracture has not been performed. The fracture of the maxilla not uncommonly passes through the infra-orbital foramen, and the nerve is subject to gross trauma. In Case 2 so badly was the nerve damaged that it was thought advisable to cut it off short, rather than allow it to become involved in scar tissue. This patient made an excellent recovery, and was free from pain when seen three months later.

**c. Eye Complications.**—Of these diplopia is the most important. In Cases 1, 10, and 14 normal vision was restored after successful reduction of the fracture. That diplopia does not clear up if the fracture is not reduced has been shown by Eckhoff (1940). Late restoration of the orbital floor rarely overcomes the diplopia, and in these cases, if the symptom is severe, it may be necessary to suppress the eye (McIndoe, 1941).

Damage to the eye resulting from loss of the normal protecting buttress is liable to occur, but we have not personally seen this. Discomfort resulting from an excess of light entering the eye from the temporal side, owing to depression of the orbital margin, has been described. This symptom was noted in Case 6 before operation.

### SUMMARY

1. Various types of fracture of the zygomatic tripod are described in a series of 14 patients treated in the Royal Naval Medical Service.

2. The salient points in clinical and X-ray diagnosis are given.

3. These fractures are classified into three main groups, according to the direction of the traumatizing force.

4. The value of the canine fossa approach in the reduction of this group of fractures is emphasized.

5. In cases where the bone fragments are loose, various methods of fixation to maintain reduction are outlined.

In conclusion we thank our colleagues who have taken part with us in the handling of these cases, and especially Surgeon Captain J. F. M. Campbell, R.N., Surgeon Commander R. Wear, R.N.V.R., and Surgeon Lieutenant Commanders D. R. Maitland, R.N.V.R., H. B. Howell, and C. A. Grant, R.N.V.R., for their radiographs, sometimes taken under considerable difficulties. Prints from the X-ray negatives were made for us by S. B. A. Whitley, F.R.P.S.

The authors are indebted to Vice-Admiral Sir Sheldon Dudley, F.R.S., the Medical Director-General, for permission to publish this paper.

### REFERENCES

- ECKHOFF, NILS (1940), *Guy's Hosp. Gaz.*, **54**, 300.  
 GILLIES, SIR HAROLD, KILNER, T. POMFRET, and STONE, D. (1927), *Brit. J. Surg.*, **14**, 651.  
 HODGSON, H. GRAHAM (1936), *Brit. J. Radiol.*, **9**, 106, 637.  
 IVY, ROBERT, H., and CURTIS, LAWRENCE (1938), *Fractures of the Jaws*, 2nd. ed. London.  
 KILNER, T. POMFRET (1942), *Proc. R. Soc. Med.*, **35**, 513.  
 LEEGAARD, TRULS (1939), *Nord. Med.*, **2**, 1131.  
 LEFORT, RENE (1901), *Rev. Chir., Paris*, **23**, 208, 360, and 479.  
 MCINDOE, A. H. (1941), *Brit. Dent. J.*, **71**, 235.

## RUPTURE OF THE PANCREAS

BY AIR VICE-MARSHAL GEOFFREY KEYNES, R.A.F.V.R.

SENIOR CONSULTANT IN SURGERY TO THE ROYAL AIR FORCE

RUPTURE of the body of the pancreas by external violence is not common when unassociated with injury to other viscera. If it is in association with other injuries the victim is unlikely to survive, and so in general there are few recorded instances of successful surgical treatment of this accident. When the body of the pancreas is torn, usually by being crushed against the vertebral column, the duct of Wirsung is likely to be injured too, and pancreatic fistula will follow drainage established by surgery. Mocquot and Costantini (1923) collected from the literature 30 examples of injury by violence to the pancreas alone. Of these, 21 were treated surgically, with 16 survivors; of 9 who were not operated on, all died. The initial treatment must therefore unquestionably be surgical. The common sequela is the formation of a pseudo-cyst of the pancreas or a persistent pancreatic fistula.

In the present communication two instances of rupture of the pancreas and its duct are described. Both were uncomplicated in the first place, but one patient developed a persistent fistula, and both had serious complications during the post-operative course. They have nevertheless survived, and illustrate the astonishing resilience of the young human body in the face of almost the worst that fate can do to it. The second of these histories is of particular interest because it is most probable that the rupture of the pancreas was due to under-water blast—apparently the only example of this injury that has yet been described.

## CASE REPORTS

*Case 1.*—Flight-Sgt. W., aged 20, was riding a bicycle at night across an aerodrome in Malta on Aug. 11, 1942. The night was dark, and he had fixed an electric torch between his trousers and his shirt to light his way. This was insufficient to save him from colliding with a boom placed across the runway. The torch was violently impacted in his epigastrium, and he developed signs of an acute abdominal crisis. He was admitted to a Military hospital, and an operation was immediately performed by Major Shucksmith, R.A.M.C., who found a rupture of the body of the pancreas over the vertebral column. No other viscus was injured, and drainage to the region of the injury was established. The fistula tended to heal spontaneously and, in fact, closed for a time, but three months after the injury it was found that a large pseudo-cyst had formed. This was opened and drainage again established on Nov. 4. He was soon afterwards transferred to the United Kingdom, and was admitted to a Royal Air Force hospital under Squadron Leader Flavell on Nov. 24, 1942. The patient was then found to have a triradiate scar with its upper and lower limbs between the xiphisternum and the umbilicus, and a lateral limb extending across the left rectus towards the loin.

Near the midline was a fistula pouring out a profuse discharge of pancreatic secretion with excoriation of the skin, but the patient's general condition was good. Squadron Leader Flavell injected lipiodol through a tube into the sinus and demonstrated by X-ray a small cavity under the skin leading leftwards by a narrow track into the duct of Wirsung, two-thirds of this being clearly shown with its lateral branches (*Fig. 215*). No lipiodol reached the right-hand part of the duct.



FIG. 215.—*Case 1.* Radiograph of lipiodol injection of pancreatic fistula.

It has been stated by Mocquot and Costantini (1923) and by Lahey and Lium (1937) in their reviews of pancreatic injuries that a fistula may heal spontaneously in the course of weeks or months. But this must depend on the patency of the duct as a whole, and we had already been convinced by the X-ray examination of our patient and by his past history that this fistula would not heal spontaneously. None of the lipiodol had passed into the duct to the right of the injury, so that the greater part of the secretion of the gland was without access to the duodenum, and was bound to come to the surface until something was done to divert it. Two possible courses seemed to be open to us: (1) to excise the body of the pancreas to the left of the rupture; (2) to attempt implantation of the duct into some part of the alimentary canal. Of these two, the second was the more conservative,

## RUPTURE OF THE PANCREAS

301

and possibly the less hazardous owing to the scarring in the abdominal wall and in the pancreas itself, which would interfere with free access to the gland and reduce its mobility.

R. M. Janes reported in 1935 what he believed to be the eighth successful instance of implantation of a pancreatic fistula into the stomach, "which, as far as one could discover, has been the only successful

in it during dissection. A small rubber tube was inserted in the track, and left there while the fistula was implanted in the wall of a loop of jejunum, which was brought up behind the colon to meet it. The junction was made as sound as possible with interrupted sutures, and the rubber tube was left in position. The abdomen was closed, with drainage down to the site of implantation.

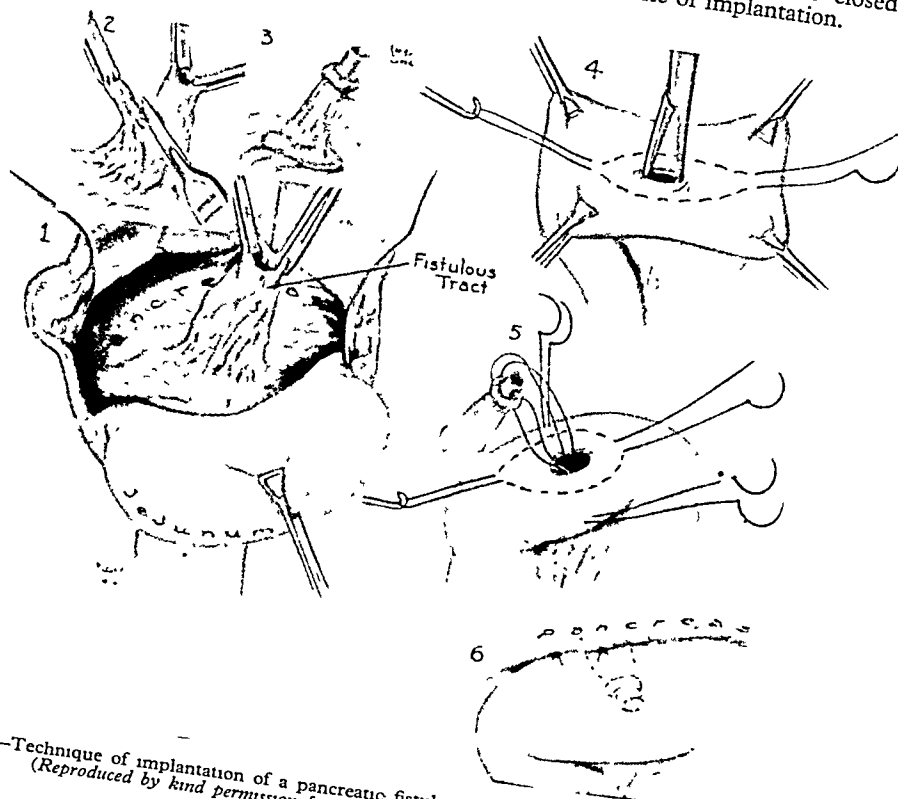


FIG. 216.—Technique of implantation of a pancreatic fistula in the jejunum. (After Lahey and Lium.)  
(Reproduced by kind permission from "Surgery, Gynecology and Obstetrics".)

method". In this patient he had demonstrated the whole of the pancreatic duct by means of lipiodol injection, and it was apparently not obstructed.

The operation for pancreatic fistula most frequently performed has in fact been that of pancreatogastrostomy. Lahey and Lium (1937) have found in the literature records of: pancreatogastrostomy, 14; pancreatojejunostomy, 9; pancreatocholecystostomy, 1; the same, followed by cholecystogastrostomy, 1. They themselves described one more operation for pancreatojejunostomy, and an eleventh has been described by Chapman (1941). There has only been one post-operative death in this series.

Implantation of the fistula in the jejunum would seem to be a physiologically sounder operation than implantation in the stomach, and our patient was accordingly treated by this method on Dec. 8, 1942, the technique described by Lahey and Lium being followed as far as possible (Fig. 216). The fistulous track was dissected backwards and was found to pass between the stomach and the transverse colon through the gastocolic ligament. The patient was young and spare, so that the track proved to be uncomfortably short. As it consisted only of friable connective tissue, its wall tended to break when it was detached from its surroundings, and two openings were made

The patient's post-operative course was uneventful. There was a semipurulent discharge for a few days, but this soon dried up, and there did not appear to be any leakage of pancreatic secretion. The rubber tube left in the fistula was not recovered from the faeces, and it remained uncertain whether it had been voided through the intestine or not. The patient was discharged from hospital on Feb. 2, 1943.

He appeared to be quite well for a time until, on April 14, he again developed signs of acute peritonitis. Leakage of pancreatic secretion was naturally suspected, but laparotomy showed only a mild peritonitis with some thick pus, containing staphylococcus, in the pelvis. The site of anastomosis was examined and found to be sound. The cause of the peritonitis was not determined, and the patient made a rapid recovery except for a pulmonary embolus which nearly caused his death on the tenth day after operation.

He remained well for four months and then he experienced an attack of nausea and retching on Aug. 14. He vomited several times during the next eight days, but no other signs of abdominal trouble were detected. Brief attacks of nausea and retching occurred four and five months later, but the patient has been quite well for the last six months. A barium

meal examination on April 21, 1944, was reported as showing some deformity of the first part of the duodenum, but no other abnormality was found in the intestinal tract, and there was no delay in the passage of the meal at any point.

*Case 2.*—Sgt. McD., aged 22, an air-gunner in the R.A.F., was engaged in operations in a Sunderland flying-boat over the North Sea in August, 1943, when the aircraft attacked a U-boat with depth charges. The flying-boat succeeded in crippling the U-boat and at the same time lodged one of its depth-charge bombs in the conning tower. Simultaneously the aircraft was hit by anti-aircraft fire from the U-boat and crashed into the sea. Some of the crew were killed, but others, including Sgt. McD., were thrown into the water unhurt. He stated that he was momentarily stunned by the crash, but when he found himself floating upright in the water, supported by his Mae West belt, he felt perfectly normal. He was then floating in the water about 400 yards from the U-boat, which he watched as it sank. When the U-boat reached the appropriate depth, the bomb in the conning tower exploded, and Sgt. McD. at that moment felt a peculiar sensation in his abdomen, which he described on several occasions as a "rumbling in the belly". Other members of the crew, who had gunshot wounds, were also in the water, and felt the concussion, though they suffered no injury from this. Sgt. McD. did not at the time experience anything more than slight pain, but when, half an hour later, he had been hauled up the side of a naval craft by means of a rope under his armpits, he found he was unable to stand. He was treated for shock, and sixteen hours after the crash was admitted to the Royal Air Force Hospital in Iceland under Squadron Leader John Hughes. He was then found to be showing all the evidence of an intraperitoneal hæmorrhage, with a hæmoglobin reading of 72 per cent.

Laparotomy was done under general anaesthesia  $3\frac{1}{2}$  hours after admission to hospital and a blood transfusion was given at the same time. Approximately one pint of free blood was found in the peritoneal cavity, with retroperitoneal hæmorrhage in the upper right quadrant and a tear in the peritoneum for about 5 in. on the outer side of the hepatic flexure of the colon. The posterior abdominal wall was examined through this tear, but no obvious bleeding points were seen. The pancreas was not swollen, and no other viscera appeared to be injured. The retroperitoneal space was drained through a stab in the loin, the colon was stitched back in its normal position, and the abdomen was closed. The patient was given 5 pints of blood by intravenous drip during the next 36 hours, and a little blood drained through the loin, the tube being removed after 72 hours.

He made a good recovery, and on the tenth day was feeling remarkably well, when a large fluid swelling was noticed in the epigastrium; this was regarded as a pseudo-cyst of the pancreas. On the eleventh day he developed all the signs of acute intestinal obstruction with a rising pulse-rate. A second laparotomy was performed by Squadron Leader Hughes under spinal analgesia. It was found that the lesser peritoneal sac was tensely filled with fluid, which had obliterated the foramen of Winslow and obstructed the colon in the region of the splenic flexure. The lesser sac was opened through the gastrocolic ligament, and more than three pints of muddy fluid was evacuated. The pancreas, when examined through this opening, was found to have a vertical tear  $1\frac{1}{2}$  in. long through the middle of the

body. The intestinal obstruction had been immediately relieved by letting out the fluid, and the abdomen was therefore closed at once with drainage of the lesser sac through the gastrocolic ligament. On the following day the pulse-rate was still high, but as the hæmoglobin reading was within normal limits no further blood was given. Instead, a slow intravenous drip of normal saline was started, and immediately changed to a solution of dried serum of normal strength. When 300 c.c. of this had been given, the patient suddenly became unconscious, with cyanosis, shallow respiration, profuse sweating, and an imperceptible pulse. No further serum was given, as anaphylaxis, following sensitization by the blood transfusion ten days before, was suspected. The patient remained in the same critical condition, almost pulseless, for the next 60 hours. Adrenaline, ephedrine, and coramine had no effect whatever. An intravenous drip of saline with occasional addition of glucose was continued throughout this time, 12 pints being given in all. At length, after 60 hours, consciousness returned, the pulse volume improved, and cyanosis disappeared. Soon afterwards the patient was again convalescent.

A transient glycosuria was noticed, but the blood-sugar curve was found to be normal, a leakage of sugar into the urine occurring at 80 mg. concentration in the blood. The fat content of the faeces was also increased for a time, though the loss of pancreatic secretion did not last for long, the drainage from the lesser sac becoming rapidly less and ceasing after seventeen days.

Meanwhile, however, the patient's surgical misfortunes were not yet at an end. Ten days after the second laparotomy he again developed signs of intestinal obstruction, and the abdomen had to be opened by Squadron Leader Hughes for the third time, this being done under pentothal anaesthesia. A lower left paramedian incision gave access to an engorged and distended loop of gut, which proved to be a volvulus of the small intestine, originating in an adhesion of the intestine to the root of the mesentery. The adhesion was freed, the volvulus reduced, and the abdomen closed with very little disturbance to the patient.

One month later Sgt. McD. was getting up, and after convalescence was transferred by air to the United Kingdom, where he was seen by the writer on Nov. 5, exactly three months after the 'incident' in the North Sea. He was a delicate-looking young man, a native of Paddington, but, except for a mild degree of anaemia, he appeared to be quite well. His only disability was due to a ventral incisional hernia, a not unnatural complication after three emergency laparotomies within 21 days. This hernia extended from the xiphisternum to the pubes, being 12 in. long by  $3\frac{1}{2}$  in. wide, and the intestines seemed to be in contact with the skin over the greater part of its extent. After a period for convalescence he was readmitted to a Royal Air Force Hospital for repair of the ventral hernia. This operation was done on Jan. 4, 1944, the gap between the recti being bridged by a flap of fascia turned over from the left anterior rectus sheath and reinforced by sutures of fascia lata. There were no further complications, and the sergeant returned to full flying duties two months later.

## COMMENT

These two histories are of interest as illustrating a rare form of rupture by violence of the body of the pancreas, without injury to other

viscera. Both injuries were followed by a pancreatic fistula, but whereas one healed spontaneously and quickly, in spite of a series of dramatic complications, the other became permanent, and was only abolished by successful implantation of the track in the jejunum.

Discussion of the second history centres around the question of exactly how the injury was inflicted. There were two possibilities: (1) Injury by being flung against some part of the aircraft when it crashed at high speed into the sea; (2) Injury by under-water blast when the depth-charge in the U-boat exploded.

Repeated cross-examination of the witness failed to shake his assurance that when he had been flung into the water by the disintegration of the aircraft he was unaware of any sign of having been injured. It is to be noted also that he was wearing a Mae West lifebelt which covers the chest and upper part of the abdomen as far as the lower costal margin. It seems inconceivable that he could have sustained by direct impact the intra-abdominal injuries found by Squadron Leader Hughes at operation without showing also some sign of bruising of the parietes. There was, however, no external injury whatever. On the other hand, all the facts would fit in with the supposition that the intra-abdominal injuries were caused by under-water concussion. Rupture of the pancreas, it is true, has not yet been described in association with this form of violence, though the tearing of the peritoneum and the retroperitoneal hæmorrhages are characteristic injuries. Neither did this man have the transient paralysis of the legs described by Cameron, Short, Wakeley and (1943) as commonly occurring with under-water blast injury; but this is not always present. It is believed that a water-born concussion can be transmitted to the posterior abdominal wall through the viscera

almost unchanged, and no protection against this would be afforded by the lifebelt. It is to be noted that the only sensations remembered by the witness were registered at the time of the explosion. There are many variable factors determining the force with which the concussion is transmitted through the water, particularly the distance and the initial force of the explosion. The distance of 400 yd. given in the present history is that estimated by the witness at the time he was floating in the water, and was obviously liable to error. However this may be, it has been demonstrated by Williams (1942) that blast effects are conveyed much farther in water than in air—that is to say, the pressure is transmitted with far less alteration over a given distance than it is in air. Although it cannot be completely proved that in the present instance the rupture of the pancreas was due to the under-water concussion, it appears to me to be so probable that I feel inclined to accept it as the true explanation of the events.

I am indebted to Major Shucksmith and to Squadron Leader Hughes for notes on the earlier parts of the histories of the two patients. It is to their skill and persistence that both men owe their lives.

#### REFERENCES

- CAMERON, G. R., SHORT, R. H. D., and WAKELEY, C. P. G. (1943-4), *Brit. J. Surg.*, **31**, 51.  
 CHAPMAN, C. L. G. (1940-41), *Ibid.*, **28**, 633.  
 JAMES, R. M. (1934-5), *Ibid.*, **22**, 296.  
 LAHEY, F. H. and LIUM, R. (1937), *Surg., Gynec. Obstet.*, **64**, 78.  
 MOCQUOT, P., and COSTANTINI, H. (1923), *Rev. Chir.*, **61**, 289.  
 WILLIAMS, SURG. CMDR. E. R. P. (1942-3), *Brit. J. Surg.*, **30**, 38.

## A GASTROSCOPIC CONTROL OF THE TREATMENT OF GASTRIC ULCER BY DUODENAL FEEDING

By HARRY FREEMAN

SENIOR CLINICAL ASSISTANT, SURGICAL DEPARTMENT, PRINCE OF WALES' HOSPITAL; SURGEON, E.M.S.; GASTROSCOPIST TO LONDON COUNTY COUNCIL

THE conservative treatment of chronic gastric ulcer has undergone many changes within the past thirty years; new diet régimes and fresh neutralizing agents with highly exalted virtues have been introduced, yet only too frequently recurrence has followed, sometimes with added complications, so that an alternative method of treatment to the one which has apparently failed is sought for and adopted.

In many instances, surgical procedures have been resorted to, frequently to be followed by symptoms as bad as, or worse than, those for which the patient originally sought advice.

There is, of course, no specific therapy in the treatment of this malady, but in adopting a particular régime one must aim at a treatment which is rational as well as practical, and that which is chosen must provide for a more speedy and permanent result than that obtained with any other method available; at the same time there should be the minimum of interference with the economic life of the patient during this treatment.

A review of the more popular ulcer régimes provides us with a series of features all dealing with the important problem of the reduction of

the gastric juice and its acidity, and upon which the respective authors base their methods of treatment. The principles concerned aim at:—

1. Reducing the acidity of the gastric juice.
2. Diminishing the amount of gastric juice, and so its corresponding free acid.



FIG. 217.—Case 1. Ulcer on greater curvature of stomach, note suspicious looking urea on lower edge of ulcer, which later proved to be innocent.



FIG. 218.—Same case after 3 weeks of duodenal feeding, ulcer healed with scar formation. Malignancy definitely ruled out.

3. Neutralizing the amount of free acid by intensive alkali administration.

In the first instance we have, as an example, the Lenhartz diet or Langdon-Brown's modification thereof; in the second, that advocated by Hurst (1928), MacLean (1928), and others who, in addition to a carbohydrate diet, which in itself reduces the flow of gastric juice, advocate the use of olive oil; thirdly, Sippy and his followers advocate the intensive use of alkalis in order to neutralize completely the free acid secreted. Although some diminution in the acid content of the gastric juice does occur with a carbohydrate diet, and also in the first instance by the presence of fat in the stomach, a fact leading some authors to prescribe olive oil, yet it has been shown by Pavlov, Rehfuess, and others, that shortly after the initial inhibitory effect of the fat, a very abundant and prolonged flow of gastric juice takes place.

It is generally assumed that neutralization of the gastric acidity is the ideal condition to be aimed at in order to ensure rapid healing of a chronic ulcer; there is, however, no proof that a high alkaline content produced by intensive alkali therapy, even if this were constant, is a determining factor in the healing. In fact, alkalis produce secondary acid secretion, and are known to be second only to histamine in their power to stimulate this flow of acid, and Wosika and

Emery (1936) have estimated that fifty times as much alkali as would neutralize all acid normally secreted by the stomach is given in the régime of Sippy; yet, even this amount does not control the acidity! It has also been shown that aluminium products introduced within recent years as neutralizing agents have definite adverse effects, for they produce a disturbance in the proper absorption of inorganic phosphates from the intestinal tract, with consequent upset of calcium metabolism (Freeman et al., 1941).

The problem, therefore, associated with the treatment of uncomplicated gastric ulcer appears to be wrapped up in an attempt to minimize the secretion of gastric juice and its acid content. But although the degree of gastric acidity bears no relation to the symptoms, or an indication of the prognosis (Brown and Dolkart, 1937), yet clinical experience has shown that a reduction in this acidity is of primary importance in the healing of the chronic ulcer. Hence the numerous acid-reducing régimes and the large number of neutralizing agents in use.

Another important feature in treatment is the relationship between vitamin C and chronic ulcer: Portnoy and Wilkinson (1938), who investigated a series of cases of peptic ulceration,

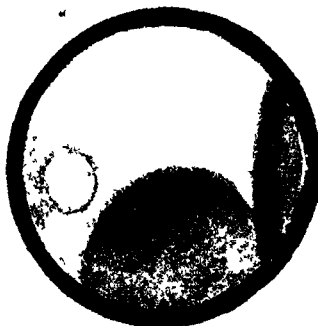


FIG. 219.



FIG. 220.

FIG. 219—Case 4. Ulcer on lesser curve just above angulus, floor of ulcer covered with slough. Note clean-cut edge with reddened margin.

FIG. 220—Same case 3 weeks later, ulcer considerably smaller, note radiating folds indicative of healing.

FIG. 221.—Same case after 5 weeks of treatment; ulcer completely healed and epithelialization has taken place.



FIG. 221.

showed that a severe vitamin-C deficiency was present in all these cases, and this deficiency was even more marked in those cases in which hæmatemesis had occurred. This deficiency may, of course, be due to the too restricted diet adopted during treatment, but what is more important is that oral administration of vitamin C is useless in conjunction with alkali therapy, as its efficacy is immediately destroyed by sodium citrate, so frequently prescribed with milk, and by other alkalis.

The physiological activity of the stomach has been studied by many workers, and Carlson and Litt (1924) have shown that in the absence of food there is very little gastric secretion, and what there is contains very little hydrochloric acid.

The problem of pain may also be considered at this stage. In Hurst's opinion (1929) the pain associated with chronic gastric ulcer is due to an increase in pressure in the proximal portion of the stomach, the obstruction at the site of the ulcer being due to a spasmodic hour-glass constriction. Carlson (1917), on the other hand, showed that plain water, if swallowed, gave rise to an increase of gastric tone which was accompanied by uninterrupted contractions and pain. This phenomenon is undoubtedly due to an increased sensitivity of the neuromuscular mechanism in the presence of an ulcer, for water administered to a healthy person caused a cessation of gastric contractions. In the light of these experiments,

which gives complete rest to the stomach, so that secretion is at a minimum and pain assuredly prevented, and which at the same time maintains the strength of the patient. It is the adoption of a fundamental principle in treatment—namely,



FIG. 224.—Case 3. Penetrating ulcer extending from lesser curve of body on to antrum. There is severe localized hypertrophic verrucose gastritis in antrum, which also involves the greater curvature of body.

FIG. 225.—Same case 6 weeks later, showing ulcer completely healed. Note puckering of angulus due to scarring. Air bubble seen in top right-hand corner. Fold of mucosa obscures antrum

complete rest to an inflamed organ—and in recommending duodenal feeding the author makes a renewed attempt to popularize the method originally advocated and practised by Einhorn in America and Ernest Young in London, and periodically by many others in this country with great success, its only drawback being that it requires a little extra trouble on the part of the patient's attendants.

Successful healing of an ulcer does not necessarily spell the end of the doctor's duty to his patient: the risk of recurrence is indeed a very real one, but it may be said that a very large number of recurrences are not recurrences at all, but lesions which have never completely healed. Hurst (1929) says, "It is obvious that active treatment must continue until *healing is complete*. In the past, medical treatment has been frequently unsuccessful because the treatment was often not founded on a knowledge of the pathogenesis, and was consequently not sufficiently thorough because it was rarely continued until healing was complete".

In a large number of cases, final X-ray examination after a course of treatment is negative, whereas a very shallow niche exists which does not fill with barium and so is not visualized. In the absence of symptoms in a patient who says he feels quite well, and in whom a negative X-ray is reported, there is therefore no hesitation in discharging him as cured. It is these incompletely healed cases which return to be labelled

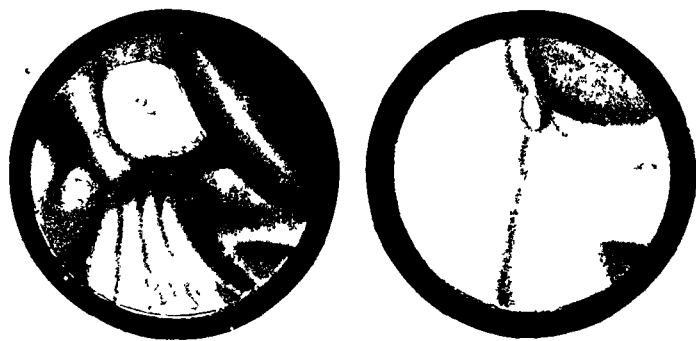


FIG. 222.—Case 6. Control case, 'gastric diet'. Early penetrating ulcer on lesser curvature above angulus; note hitched-up appearance of latter caused by scarring. Numerous radiating folds are seen with patches of grey mucus filling the valleys, denoting superficial gastritis. A smaller ulcer is seen on the left. Part of the larger lesion is obscured by an oedematous fold.

FIG. 223.—Same case after 6 weeks' treatment with ulcer diet; the ulcer is very much smaller and final healing may be further delayed

it must be assumed that fluid entering the unhealthy stomach gives rise to increased tonus and contractions which are responsible for the production of pain.

If these important facts are interpreted correctly we can produce a method of treatment



as 'recurrence'. The only certain way of determining whether the ulcer has healed or not is by gastroscopy. The surface of the mucosa can be readily seen, together with any pathological exudates, hæmorrhages, or erosions which may also be present. Although radiology is still the



FIG. 226.—Case 7. Large gastric ulcer on posterior wall of lesser curvature; a long history of symptoms with loss of periodicity; the gastroscopic picture of the base shows it to have penetrated into the pancreas. Mucosa paler than normal on account of severe anæmia.

standard method of choice in the diagnosis of an ulcer, the author has found a number of ulcers on gastroscopy which have been missed by the radiologist; this may be accounted for by failure of the barium to fill the crater because the floor is already filled with slough or mucus. Patients who therefore present ulcer symptoms and in whom a negative X-ray examination has been reported should be gastroscopied, and the examination repeated subsequently before cessation of treatment is contemplated. Any small residual ulcer, if present, can be seen through the gastroscope, and may not be shown by a barium meal; the ulcer increases in size if intensive treatment is prematurely stopped. This procedure, then, undoubtedly reduces the incidence of 'recurrence'. The author's series of 15 cases were all gastroscopied before and during treatment and again finally before discharge, and in no case was the ulcer considered healed until the crater had disappeared and epithelialization had taken place. A number of cases of chronic ulcer were treated simultaneously by other régimes, but in no instance did the associated gastritis disappear so readily or the ulcer heal so rapidly as those in which duodenal feeding was carried out.

The average time required for healing, which was confirmed gastroscopically, was four weeks: but in some cases the interval was a little longer: it may be stated that the more rapidly a chronic ulcer heals the more permanent is the result likely to remain. The types of chronic ulcer which respond most readily to the régime of duodenal feeding are:—

- a. Those of moderate or long duration without complications.
- b. Ulcers which have given rise to occasional hæmatemesis.
- c. Early cases of penetrating ulcer.

Success depends upon conscientious and careful handling of all cases; it depends also upon the care with which the patient follows any post-ulcer régime, the importance of which should be pointed out to him before discharge.

Failures are usually due to: (1) Lack of co-operation by the patient, especially in the early stages of treatment; this lack of co-operation often includes surreptitious feeds—food brought by relatives who believe they are being kind to the patient. (2) Deep penetration into the pancreas. (3) An incorrect diagnosis, i.e., malignant ulcer or early malignant change in a chronic ulcer.

There is, of course, no direct evidence that duodenal feeding provides for a more permanent cure than when other methods of treatment are used: but a breakdown of the old ulcer is far less likely because of the rapidity with which the original lesion heals under conditions in which treatment is carried out.

It is advisable to keep the patient in bed for the first fortnight after treatment is begun; after this interval he is allowed up gradually. Many patients have carried on their work during treatment by duodenal feeding. It is not uncommon for a patient to agitate for removal of the feeding tube at the end of a few days because he has lost his pain and feels better. Pain disappears in almost all cases within forty-eight hours of



FIG. 227.—Case 8. Large deep ulcer on lesser curvature close to stoma of gastro-enterostomy; indurated area on stomal edge of ulcer strongly suspicious of malignancy.

FIG. 228.—Same case 4 weeks later, rapid change in appearance; malignancy change well shown. Stoma is obscured by œdematous fold running across field of vision.

commencing tube feeds; rarely it may be necessary to give atropine hypodermically. Wyard (1942) emphasizes the importance of avoiding alkalis—these are quite unnecessary because symptoms disappear after a few hours of beginning treatment. If, however, pain persists after this short period, the diagnosis should be reviewed, for the possibility of a deep penetration into the pancreas

or a malignant change in the ulcer must be considered. Although this latter change can nearly always be eliminated at the initial examination, there occasionally arises a case in which it is impossible to be absolutely certain; nevertheless, he is put on treatment and gastroscopy repeated

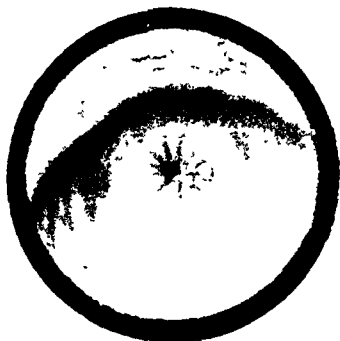


FIG. 229.—Normal stomach as viewed through the gastroscop. Stellate folds around closing pylorus through which bubbles of duodenal contents are regurgitating. Angulus is seen in upper part of picture, and above this is shown a small portion of the lesser curvature of the stomach. On the left may be seen a few comparatively straight folds of the anterior wall.

two weeks later as with all other cases. This interval is sufficient to enable one to judge (a) whether or not the ulcer will heal rapidly, and (b) the true nature of the ulcer. Should a suspicion of malignancy have arisen at the first examination, this suspicion can now be confirmed or removed altogether. I make a point of telling the patient during this examination that his ulcer is actually *seen* to be smaller; this information produces great confidence on the part of the patient and his co-operation in further treatment is easily assured.

### TECHNIQUE

The technique is that used by the late Dr. Ernest Young (1933). Preferably an Einhorn or Ryle's thin rubber tube No. 7 should be used; these are softer and more flexible than other types and are therefore less liable to irritate the pharynx. The tube is passed in the morning on a fasting stomach. It is proved in the duodenum if on attempting to aspirate with an attached hypodermic syringe, withdrawing the plunger is difficult and the tube collapses; as long as withdrawal of fluid is easy, the tube still lies in the stomach. Alternatively, a little milk coloured with coffee or a few c.c. of weak solution of cochineal may be put into the stomach before the end of the tube reaches the duodenum; aspiration of the coloured fluid is naturally impossible with the tube in its correct position.

There are three sets of markings on the tube; the first is 12 in. away from the metal bulb, the second is 23 in., and the third 30 in. away. The bulb is placed on the tongue with the patient in a sitting position, the operator standing behind the patient, whose head he supports. The patient is

instructed to swallow the tube, which is gently pushed along, and when the first of the markings is reached the tube lies just in the stomach. The tube is further coaxed until the second series of ring markings is reached; it now lies in the region of the pylorus. A few sips of water are given, and at this stage the action of the pylorus forces the tube through the sphincter into the duodenum. When the 30-in. mark is reached, the tube lies well down in the third part of this viscus. Its presence there is confirmed by the above tests. The whole procedure may take from ten minutes to several hours, but as a rule, if there is no pyloric obstruction, the tip of the tube enters the duodenum within ten minutes.

As Young points out, the operator *does not* pass the tube into the duodenum; peristalsis of the stomach does this once the tube has entered this organ. The end of the tube is anchored behind the ear.

A glass container into which the feeds are put, is hung 3 ft. above the level of the head of the bed; to it are connected a rubber tube and tap, the distal end of the tube being connected by a glass tube to the duodenal tube. The following points should be observed:—

a. The tap is adjusted so that the feed takes from 20 to 30 minutes.

b. All feeds must be strained through gauze and given slightly warm.

c. Before and after feeds a 10-c.c. syringe of water, followed by a syringe of air, must be passed down the tube to keep it clear.

d. After feeding, the duodenal tube is disconnected, looped so as to occlude it, and fixed behind the patient's ear. A small spigot may be put in the end of the tube.

e. The feeding apparatus must be cleansed with cold water after each feed.

f. The tube is retained for 21 days; it is then withdrawn and the patient is gastroscopied. If healing is complete, he commences the 'initial diet' (p. 308); if not, the tube is replaced.

**Feeds.**—Nothing whatever enters the stomach; all food and medicine pass straight into the duodenum. Each feed consists of 8 oz. of milk (dried milk can be used) plus any other substance such as arrowroot, Benger's food, eggs (or dried eggs), and lactose. Some patients cannot tolerate quite this quantity, which is reduced accordingly.

Seven feeds are given daily at two-hourly intervals, starting at 8 a.m. It is a good plan to alternate the preparations used in conjunction with milk. If constipation is present give a suitable dose of cascara evacuant in the feed. Vitamin C (ascorbic acid), 150 mg. daily, should also be added.

In very nervous patients a mixture of bromide and valerian given through the tube helps to allay any anxiety or mental stress, conditions which so very often accompany peptic ulceration. Occasionally excessive salivation may render the tube intolerable; in these circumstances a hypodermic injection of atropine (gr. 1/50) once daily will overcome this difficulty.

### 'INITIAL DIET' TO FOLLOW IMMEDIATELY AFTER DUODENAL FEEDING (YOUNG)

**Breakfast** (8.30 a.m.): Scrambled egg (or dried substitute) with toast and a little butter. A cupful of weak tea, with or without milk, at end of meal. No sugar.

**Lunch** (1.30 p.m.): Flaked boiled fish, sieved potatoes, toast.

**Tea** (5.30 p.m.): Two teacupfuls of China tea without sugar, a few plain biscuits.

**Dinner** (7.30 p.m.): Breast of chicken or rabbit, sieved potatoes, toast. Junket, stewed prunes (sieved). Not more than half a tumblerful of water.

**Extra Fluid**: One hour before breakfast and lunch and on retiring, sip a tumblerful of hot water.

A gradual increase in the above diet is made until lean beef, mutton, etc., are included, as shown in the 'intermediate diet', below. No change in vegetables, however, should be made until *two months* have elapsed after commencement of the treatment.

### 'INTERMEDIATE DIET'

**Breakfast** (8.30 p.m.): Eggs (boiled, poached, or scrambled) or thin slices of lean ham; stale white bread, little butter. One teacupful of weak tea (no sugar) at end of meal.

**Lunch** (1.30 p.m.): A choice of lean cut from joint of beef, mutton; cutlets, chop, fillet steak, chicken; boiled potatoes, but no other vegetables at present. Oven toast or breakfast biscuits. Baked custard, junket, or jelly. Not more than half a tumblerful of water.

**Tea** (5 p.m.): Two teacupfuls of weak tea (no sugar) and a few plain biscuits.

**Dinner** (7.30 p.m.): As at lunch.

**Extra Fluid**: As in the 'initial diet'.

### AFTER-CARE AND PREVENTION OF RECURRENCE

Cases which have been treated successfully, occasionally relapse because adequate advice as to the future care is withheld at the time the patient is discharged. It must be remembered that he still has his ulcer diathesis, and foci of infection in the mouth, nasal sinuses, or appendix, if present, should be dealt with. Most workers are agreed that these conditions are accessory factors in the predisposition to ulcer formation, and their elimination cannot but help to reduce the incidence of recurrence. Excessive smoking and alcohol are also detrimental, and stress should be laid on the importance of chewing all food thoroughly so as to avoid trauma to a vulnerable gastric mucosa. The post-ulcer régime should be followed for six months after complete healing has taken place.

### SUMMARY

1. Complete rest to the stomach is the ideal condition consistent with a rapid healing of an

ulcer; very little secretion occurs in the state of rest.

2. Early relief from pain is assured by the absence of stimuli from food or fluid to a hyper-sensitive neuromuscular mechanism.

3. Duodenal intubation provides complete rest to the inflamed organ whilst the nourishment and strength of the patient is maintained.

4. Gastrosopic control is of importance because:—

a. It is the only way of being certain that the ulcer has *completely* healed: incidence of 'recurrence' is thus reduced.

b. It is the only certain way of detecting an early malignant change in a gastric ulcer.

c. Should healing be unduly delayed the cause—e.g., a deep penetrating ulcer—can easily be ascertained and time not wasted by persisting with conservative measures.

In conclusion, I would like to thank Mr. William Tanner, Prince of Wales' Hospital, for his co-operation and for providing facilities for carrying out these investigations and the treatment of the cases under his care, and for his kindness in reading the proofs. My thanks are also extended to Dr. W. R. M. Turtle, Medical Superintendent, St. Mary Islington Hospital; and to Mr. Ivor Price, St. Mary Islington Hospital, for his selection and conscientious supervision of a number of cases from which some of this material was provided. To the young artist, Mr. P. Startup, I offer my appreciation of the patience shown during the gastrosopic examinations, and thank him for the beautiful paintings he has produced from his impressions at the time of these examinations.

### REFERENCES

- BROWN, C. F. G., and DOLKART, R. E. (1937), *Arch. intern. Med.*, **60**, 680.  
 CARLSON, A. J. (1917), *Amer. J. Physiol.*, **45**, 81.  
 — — and LITT, S. (1924), *Arch. intern. Med.*, **33**, 281.  
 FREEMAN, S., and FREEMAN, W. M. (1941), *Amer. J. Physiol.*, **133**, 281.  
 HURST, A. F. (1928), *Brit. med. J.*, **2**, 779.  
 — — and STEWART, M. J. (1929, a), *Gastric and Duodenal Ulcer*, 160.  
 — — — (1929, b), *Ibid.*, 387.  
 MACLEAN, H. (1928), *Digestion and Gastric Diseases*, 151.  
 PORTNOY, B., and WILKINSON, J. F. (1938), *Brit. med. J.*, March 12, 554.  
 WOSKA, P. H., and EMERY, E. S., jun. (1936), *Ann. intern. Med.*, **9**, 1070.  
 WYARD, S. (1942), *Med. Pr.*, **208**, 70.  
 YOUNG, E. (1933), *Proc. med. Soc. Lond.*, **56**, 133.

## CAROTID LIGATION FOR INTRACRANIAL ANEURYSM

## REPORT OF A CASE STUDIED BY ELECTRO-ENCEPHALOGRAPHY

By LAMBERT ROGERS, SURGEON CAPTAIN, R.N.V.R.

*"The possible occurrence of cerebral disturbance has invested a simple technical procedure with a gravity associated with but few operations."*—Rudolf Matas (1911).

THIS statement is as true to-day as when it was first made. Geoffrey Jefferson (1938) has emphasized the liability to hemiplegia following carotid ligation for cases of saccular intracranial aneurysm, even in young subjects, and reminded us that however true it may be that with aneurysms of the limb arteries the collateral circulation is likely to be more efficient, there is evidence that the reverse holds in the case of aneurysms inside the skull. Cases of carotid ligation are, therefore, well worthy of investigation and record.

## CASE REPORT

**HISTORY.**—A healthy man, aged 22, while driving a car had a sudden severe headache which necessitated his stopping and handing over to a passenger. For a fortnight previously he had noticed occasional twitching of his right eye. On waking on the morning after his attack of severe headache, he was unable to open the eye voluntarily. When the upper lid was forcibly raised the vision was found to be blurred. The condition gradually cleared up and two years later he was drafted to India, where he served for nearly three years, but in May, 1943, he suffered from attacks of pain behind the right eye and was invalidated home.

**ON EXAMINATION.**—He was a well-built man with ptosis and a dilated, inactive pupil on the right side. Movements of the eyeball were defective and

**TREATMENT.**—From April 5 until April 28, 1944, digital compression of the right common carotid was performed, at first for five minutes, later as long as twenty minutes, each day.

**Operation.**—On April 29 the right common carotid artery was exposed under novocain infiltration and



FIG. 231.—Anteroposterior X-ray film showing aneurysm well to the right of the midline.



FIG. 230.—Lateral X-ray film of skull showing calcification in sac of aneurysm.

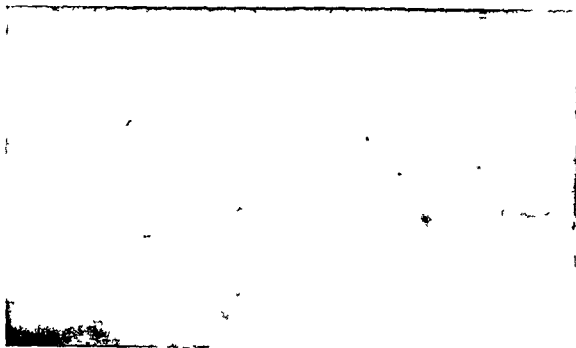


FIG. 232.—Enlarged lateral view of aneurysm showing its relation to the posterior clinoid process.

the vision was J14 (left, J1). There were no other abnormal findings, but the blood-pressure was 210/100. X rays showed some calcification regarded as occurring in an aneurysm of the right internal carotid (Figs. 230-232). The cerebrospinal fluid pressure was 180 mm., its protein content well below normal, and the Wasserman reaction negative. An electro-encephalogram revealed nothing abnormal in any area either when resting or during over-breathing (W. Grey Walter).

temporarily occluded by a piece of tape surrounded by four waxed silken threads tied over it in a half hitch which was held in the beak of a curved hæmostat. The systolic blood-pressure was now 190 and remained so throughout the operation. Dynamometer readings were taken every three minutes from both hands over a period of an hour and a half and at intervals during this time electro-encephalograms were also obtained (Figs. 233, 234), and reported upon as follows: "During occlusion of the right common

carotid the right hemisphere showed slightly more prominent normal rhythms than the left; these were never outside the physiological range and towards the end of the period (1 hour 20 minutes after occlusion) the asymmetry was less marked than at first (Fig. 234). These observations suggest that the carotid occlusion did not result in any significant arterial anoxia." (W. Grey Walter.)

after ligation of the internal carotid, has been reported by the writer in a case of fistulous carotico-cavernous aneurysm (R. Parry and Lambert Rogers, 1939). In order therefore to lessen the possibility of such a delayed complication it was decided to ligature the common rather than the internal carotid, thereby leaving a trickle of blood

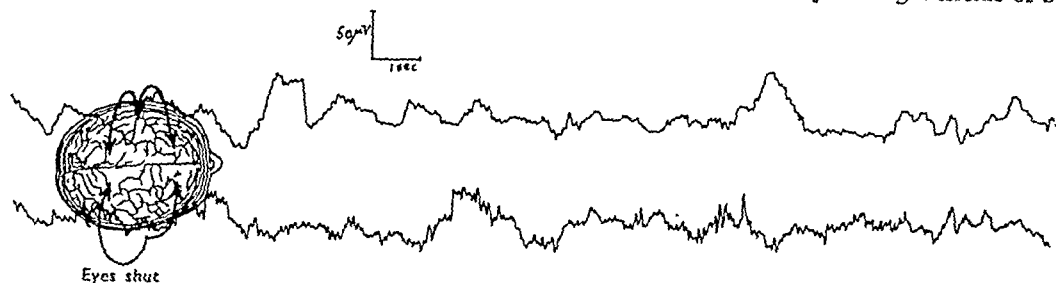


FIG. 233.—Electro-encephalogram taken during carotid occlusion. Common carotid artery closed for 50 minutes.

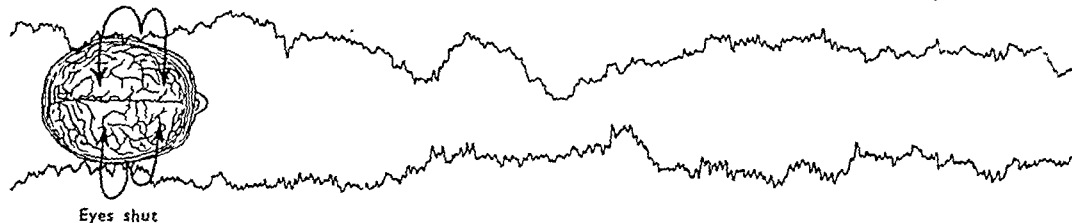


FIG. 234.—Electro-encephalogram taken one hour and twenty minutes after carotid occlusion and just prior to division of the common carotid trunk.

As neither the E.E.G. nor the dynamometer readings gave any indication of serious impairment of cerebral function, the common carotid artery was secured in two places by silk ligatures and divided between these. A striking phenomenon was the extent of the retraction of the divided ends of the vessel, so that they were separated by at least an inch.

PROGRESS.—The pain disappeared, the ptosis lessened, and the movements of the eyeball improved and with them the vision from J14 to J4. There has been no hemiplegia. An electro-encephalogram on May 20 (i.e., three weeks after operation) showed all rhythms within the normal frequency band, confirming that the carotid occlusion had no significant effect on cortical function.

### COMMENT

I can find no previous report of electro-encephalographic studies made during carotid occlusion.\* In this case these showed that during almost an hour and a half's temporary occlusion of the common carotid, no significant change in cerebral function occurred. This was supported by measurements of the strength of the hand grip made during the same interval. In such cases it cannot be said, however, that a delayed hemiplegia will not follow the occlusion. An example of this, occurring some twenty hours

through the aneurysm as in the classical operation for popliteal aneurysm performed by John Hunter on the femoral artery with the object of promoting the formation of protective laminated clots. The danger of delayed hemiplegia would appear to be greater from primary ligation of the internal carotid because, having no branches, this vessel when tied forms a long test-tube full of blood, which if it clots may, by extending upwards, obstruct its terminal branches and thereby seriously interfere with cerebral function.

The degree of longitudinal tension in the carotid artery, as evidenced by the extent of its retraction when divided, which has been commented upon in the case recorded here, suggests that this division is advisable since it reduces the local pumping action which may liberate clot from the site of a ligature applied in continuity and thus give rise to delayed embolism.

### SUMMARY AND CONCLUSIONS

A case of partly calcified intracranial aneurysm is recorded for which carotid occlusion was performed. Cerebral changes following temporary occlusion were studied by electro-encephalograms and dynamometer readings. No serious changes having been so detected, the common carotid was permanently occluded by division between ligatures with benefit to the patient by alleviating symptoms and producing no untoward effects. It is possible that this is the first case of carotid occlusion for intracranial aneurysm to be

\* Since reporting this case I have operated upon two others in which electro-encephalograms were equally helpful. In each of these, as the tracing following temporary occlusion showed no significant change, the common carotid was tied and divided without incident.

studied by electro-encephalograms and believed that such investigations may prove useful in future cases. It is suggested that the common carotid artery should be divided between ligatures rather than tied in continuity.

I am greatly indebted to Professor Golla and the staff of the Burden Neurological

Institute for their kind co-operation with this case.

#### REFERENCES

- JEFFERSON, G. (1938), *Brit. J. Surg.*, 26, 267.  
 MATAS, R. (1911), *Keen's Surgery*, 5, 321. Philadelphia: W. B. Saunders.  
 PARRY, R., and ROGERS, LAMBERT (1939), *Brit. J. Surg.*, 27, 179.

## FASCIAL SLINGING OF THE SCAPULA AND CLAVICLE FOR DROPPED SHOULDER AND WINGED SCAPULA

By G. C. DORLING

FROM THE DEPARTMENT OF SURGERY, BRITISH POSTGRADUATE MEDICAL SCHOOL, HAMMERSMITH L.C.C. HOSPITAL

IN 1927 Professor Arnold K. Henry described an operation for slinging a dropped shoulder. The condition followed division of the spinal accessory nerve during an operation for tuberculous glands of the neck eighteen months before and was successfully treated by slinging the scapula to the spines of the 6th cervical and 3rd dorsal vertebrae by means of fascial strips from the thigh.

The following two cases show how useful this method of treatment may be when the ideal neurological approach has failed or is impracticable. Both patients have been greatly relieved. The first is a case of winged scapula (serratus anterior palsy), the other of dropped shoulder (spinal accessory palsy). Henry's original method has been modified by turning up a single flap instead of making four separate incisions, and in the case of the dropped shoulder by slinging up the outer end of the clavicle as well as the scapula. The after-treatment has also been simplified.

### CASE REPORTS

*Case 1.*—E. S., aged 27, joiner, graded A.I in January, 1941, when he joined the army. In June of that year he had an operation for anal fissure, during



FIGS. 235, 236.—Case 1. Winged right scapula.

under local anaesthesia. Faradic stimulation of the nerve produced no motor response and the serratus anterior muscle responded very sluggishly to direct faradic stimulation. In November he was invalided out of the army because of winged scapula. He then received physiotherapy as an out-patient at Hammersmith Hospital, but as there was no evident improvement by May, 1942, he was admitted.

From investigations on the cadaver, Professor Henry considered it was likely that pressure at the root of the neck close to the vertebral column might injure the nerve to the serratus anterior muscle (the long thoracic nerve of Bell) where it crosses the edge of the first rib. There the nerve lies in direct contact with the rib and only becomes separated from it by muscle at a lower level. Another explanation of the aetiology is stretching of the nerve across the first

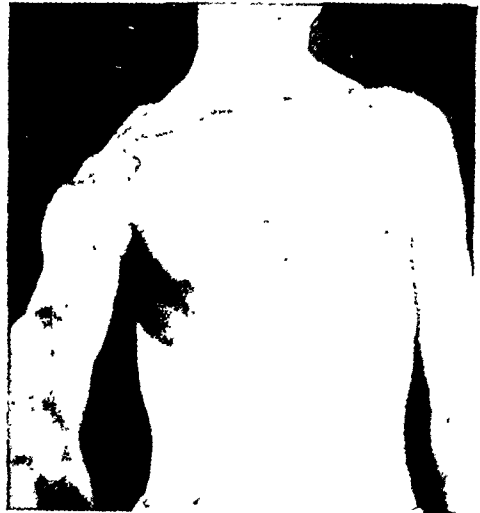


FIG. 237.—Same case. Winged right scapula angle seen above trapezius outline.

which he stopped breathing, artificial respiration being applied. Winging of the right scapula was noticed on the third post-operative day. Presumably the long thoracic nerve of Bell had been compressed at the root of the neck by the shoulder-piece of the table during the artificial respiration. In October, 1941, the long thoracic nerve was exposed in the axilla

rib at this situation. [I have recently performed this slinging operation on an airman whose winged scapula followed his supporting the wing of an aeroplane with his arm raised. It slipped, with the result that his abducted arm suddenly bore the full weight of the wing. When travelling home by train that evening, he noticed he was unable to lean back because

of winging of his shoulder-blade. This case is not included in this paper as it was performed too recently.]

On May 18 Professor Henry exposed the long thoracic nerve at the root of the neck. No neuroma was discovered. Stimulation of the nerve did not

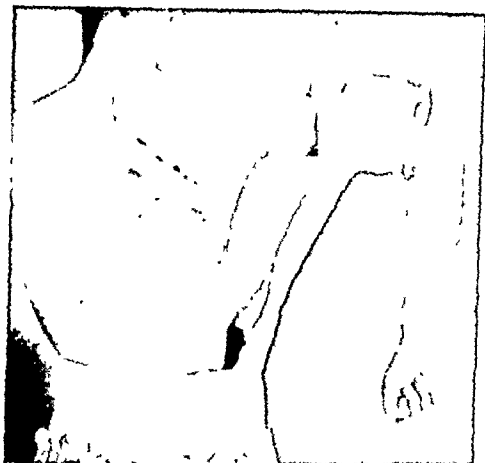


FIG. 238.—Skeletal abduction plaster allowing full elbow movements and deltoid exercises.

produce any contraction of the serratus anterior muscle. The patient came under my care in August, 1942. His disability then was: (1) Marked winging of the right scapula (Figs. 235-237); (2) Inability to raise right arm above a right angle when abducted or held forward; and (3) He could not place his right hand between the scapulae. As the neurological approach had twice been unsuccessful and the winging of the scapula was as bad as ever fourteen months after the onset, it was decided to sling the scapula to the spine by Henry's method.

On Aug. 31, under general anaesthesia by Dr. D. Spence-Sales, the patient was placed three-quarters prone on his left side with a sandbag under his chest to allow flexion of the pronated head, so exposing the back of his cervical spine. A 12-in. incision was made on the outer side of the right thigh and two  $\frac{1}{2}$ -in. strips of fascia lata cut as long as was possible, 11 in. being obtained. The gap left was easily closed without tension by continuous catgut. The two fascial grafts were placed in a swab soaked with saline. A large skin-flap was turned up from his back by an incision which ran vertically from the 5th cervical spinous process down the left side of the spine to the level of the 5th dorsal vertebra, where it curved downwards and outwards across the lower third of the scapula to 3 in. beyond its vertebral border. Reflection of this flap exposed the trapezius, covered by its fascia, the spinous processes C.6 to D.4 and the medial third of the scapula with the thick rounded supra- and infra-spinatus muscles bulging beneath the trapezius. A 1-in. incision separating the trapezius and supraspinatus was made  $\frac{1}{2}$  in. from the vertebral border of the scapula halfway between its spine and upper border. A cranial burr was used to drill a  $\frac{3}{4}$ -in. smooth hole through the scapula at this point. A similar incision and burr hole was made  $2\frac{1}{2}$  in. below the spine of the scapula, also  $\frac{1}{2}$  in. from its medial border. A pair of curved forceps was passed through the lower burr hole and a tunnel formed by passing it up deep to the trapezius to

the right side of the 3rd dorsal spinous process. A small vertical incision was made here through the origin of the right trapezius, allowing the point of the forceps to protrude. This grasped one of the fascial strips, which was withdrawn along the track. The other end of the fascia was passed round the spinous process of the 3rd dorsal vertebra deep to the supraspinatus ligaments and returned to the scapula along the same tunnel deep to the trapezius but superficial to the burr hole. Similarly the other strip of fascia was passed around the 6th cervical spinous process and through the upper burr hole. The two loops of fascia were each joined together with silk after placing the scapula in a fully corrected position by holding the hand above and behind the occiput. Both joined portions were manipulated under the trapezius. Eleven inches appeared to be about the correct length of strips for adequate fixation of the fascial sling, i.e., allowing 1 in. overlap. When doing the operation on the cadaver the 10 in. recommended by Henry was found to be rather short. The flap was sutured back in position in two layers. The skull was now covered with a plaster cap over cotton-wool and the right hand fixed to this over the occiput by plaster, leaving the fingers and thumb free. The patient found this very uncomfortable, so on the third day it was changed for a skeletal abduction plaster (Fig. 238) which kept the shoulder raised and held back while leaving the chest entirely free. Over felt padding a plaster slab was passed around the pelvis and moulded on to the iliac crests. This was made thick enough with 6-in. plaster bandages to act as a firm base. A padded ring of plaster was now fixed around the upper arm. This was connected to the pelvic band by two plaster struts running anteriorly and posteriorly respectively. These struts were made by twisting a 10-layer plaster slab (6 in. wide) around the cardboard centre of two Cellon bandages.

The patient found this skeletal plaster very comfortable and was able to walk about in it without inconvenience. It left the wound free from pressure and his chest completely free for respiration. The deltoid muscle could be seen and so regular exercise of it supervised. After four weeks the upper half of the plaster around the arm was removed, allowing him to raise the arm above the right angle, which he was able to do without any pain or winging of the



FIGS. 239, 240—Case 1, after operation.

scapula. The plaster was worn for eight weeks, after which it was replaced by a calico 'waistcoat' to keep the scapula pressed against the chest wall. This he wore for a further month.

The patient left the ward on Nov. 30 (Figs. 239, 240). On Dec. 9 it was noted that he could fully raise the arm at the shoulder in abduction and in the forward direction without any winging of the scapula

(Fig. 241). He commenced light work on Dec. 30. He is now a physical training instructor at a rehabilitation centre and suffers no disability.



FIG. 241.—Case 1, now a physical training instructor at a rehabilitation centre.

Case 2.—Mrs. E. B., aged 44, had a dropped shoulder due to division of the spinal accessory nerve during an operation for tuberculous glands of the neck



FIG. 242.—Case 2, showing right shoulder 2 in. lower than left and right scapula appearing above trapezius outline.

21 years ago. In 1933 an operation had been performed to fix the scapula to the ribs. About 1 in. of the 8th rib was freed of periosteum. A hole was drilled through the scapula. About 6 in. of peroneus longus tendon was inserted through the hole and around the rib and its ends sutured together. Her arm felt stronger after this.

After a fall in May, 1941, aching in the shoulder recurred, with tingling in the 1st, 2nd, and 3rd fingers. On Oct. 13 Professor Henry performed the fascial sling operation using two strips of fascia lata from 7th cervical vertebra and 4th dorsal vertebra to drill holes above and below the spinous process of the scapula respectively. The after-treatment consisted in a shoulder abduction spica, which she wore for a month. There was now no winging of the scapula and the patient was relieved of all her symptoms, and able to return to her work as a charwoman. She remained well until April, 1943, when after heavy lifting in a factory the shoulder began to droop, this coinciding with aching pain in the fingers and hand. On examination in July this shoulder was 2 in. lower than the left (Fig. 242). There was extreme wasting of the trapezius muscle, causing a most unsightly hollow in the right supraclavicular region when she abducted the arm (Fig. 243). A dragging ache in the shoulder was relieved by supporting her elbow. There was no winging of the scapula and Professor Henry's two grafts could be felt binding the scapula to the spine. We concluded that her symptoms were caused by dropping of the shoulder girdle from paralysis of the trapezius.

On July 26, 1943, an operation was undertaken with the idea of slinging the scapula and clavicle upwards to the spine (Fig. 244). Two 11-in. strips of fascia lata were first cut from the left thigh. The patient was then turned two-thirds over into a semi-prone position and a U-shaped flap was raised from the base of the right side of the neck, exposing the 5th, 6th, and 7th cervical spinous processes, the spine and supraspinous fossa of the scapula, and the outer half of the clavicle. Professor Henry's upper graft was seen to be in good condition. A hole was drilled with a cranial burr through the upper angle of the scapula and another through the outer end of the clavicle between the conoid and trapezoid ligaments. One fascial strip was placed through the scapula hole and around the 6th cervical spinous process and tied to itself, the sling passing deep to the atrophic fibrous trapezius. The knot was sutured with silk. The second sling passed similarly from the hole in the



FIG. 243.—Case 2, with arm abducted.

clavicle up to the 6th cervical vertebra deep to the muscles. The muscles were sutured with catgut so as to bury the grafts and the wound closed in the usual way. This patient had refused to wear any sort of plaster because the shoulder abduction spica after her previous operation had caused a plaster sore and some wound sepsis, so she was nursed in a triangular



sling applied in the St. John's Ambulance method of supporting a fractured clavicle, i.e., with the sling passing over the opposite clavicle. This sling required frequent adjustment and I would strongly recommend the skeletal abduction plaster (see Fig. 238) as being

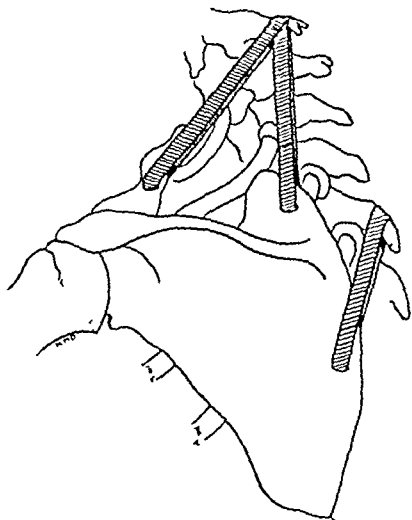


FIG. 244.—Method of slinging clavicle and scapula to spinous processes of C6 and T3 by fascial strips.

more efficient. Post-operative photographs (Figs. 245, 246) show the good cosmetic result. The dragging sensation in the shoulder was relieved and the paræsthesia in the hand disappeared. It was thought that these symptoms were of the same nature as the scalenus anticus syndrome, and were due to stretching of the brachial plexus by the downward displacement

following trauma to the long thoracic nerve treated by four strips of fascia used to sling the scapula to holes drilled in the spinous processes of the 4th, 5th, 6th, and 7th dorsal vertebra. Six months later the patient could use this upper extremity as freely as his other. F. D. Dickson (1937) reported 6 cases of high cervico-thoracic curvature with a droop shoulder treated by a very similar procedure. One fascial sling was fixed between the base of the spine of the scapula and a hole drilled in the spinous process of the 1st dorsal vertebra. His second strip of fascia ran from the spine of the scapula to the cervical muscles. The results in these 6 cases were beyond expectation. The shoulders have remained elevated in 4 cases three years and in 2 cases two years after operation. In 1 case of serratus anterior palsy he used a fascial sling to join the lower angle of the scapula to the lower fibres of the pectoralis major muscle and the anterior fibres of the latissimus dorsi muscle. Rotation of the upper border of the scapula downwards and inwards was not prevented and some dropping downwards of the shoulder persisted, so a second transplant was put in from the spine of the scapula to the cervical muscles. This gave added stability and lessened the tendency to dropping of the shoulder.

Since writing this paper I have read Berkeiser and Shapiro's report (1937) of 4 cases of alar scapula cured by resting the serratus magnus muscle in the position of relaxation for three months by means of a shoulder abduction plaster spica. This is certainly the method to use first in early cases, when recovery of the nerve is still possible.



FIGS. 245, 246—Case 2, after operation.

of the shoulder girdle. The patient is now (March, 1944) working in a war factory, the shoulder causing her no disability.

### DISCUSSION

A shoulder which is either winged or dropped may be a cause of considerable discomfort and disability. When the scapula is anchored the symptoms are relieved. Since Henry described his operation in 1927, A. Whitman (1932) has reported a case of serratus anterior paralysis

### SUMMARY

A case is reported of winged scapula treated by slinging the scapula to the spine by two fascial strips. A case of dropped shoulder was similarly treated with the addition of another fascial strip to sling the outer third of the clavicle to the 6th cervical spinous process.

I wish to record my thanks to Professor G. Grey Turner for placing material at my disposal for practising these operations on the cadaver

and for his constant encouragement in tackling difficult surgical problems.

It was while working with Professor A. K. Henry that my interest in this subject was aroused and without his kind help and advice this paper would not have been written.

I am indebted to Mrs. K. M. Doyle for the excellent sketch (Fig. 244) and to Mr. Wilmott for the photographs.

## REFERENCES

- BERKHEISER, E. J., and SHAPIRO, F. (1937), *J. Amer. med. Ass.*, **108**, 1790.  
 DICKSON, F. D. (1937), *J. Bone and Joint Surg.*, **19**, 405.  
 HENRY, A. K. (1927), *Brit. J. Surg.*, **15**, 95.  
 WHITMAN, A. (1932), *J. Amer. med. Ass.*, **99**, 1332.

# MALIGNANT TRANSFORMATION IN A PREVIOUSLY BENIGN TUBULAR ADENOMA OF THE KIDNEY

By WILLIAM BUCKLEY

HONORARY SURGEON, VICTORIA HOSPITAL, WORKSOP

THE case reports of renal adenomata in the literature are not very numerous. Gordon-Taylor (1930) records a case of an adenofibroma weighing 22 lb. successfully removed by operation. The microscopical appearances in his case showed numerous tubules lined by cubical or rounded cells, but with no evidence of malignancy.

some four years previously, when it was only about half its present size. At first he had no symptoms except constipation and flatulence with borborygmi. Appetite was good, no indigestion, no blood or mucus in the motions. For the past two years he had felt an occasional griping in the left loin and hypogastrium, especially after taking opening medicine. This pain had been getting worse during the past year. There had been no urinary symptoms except

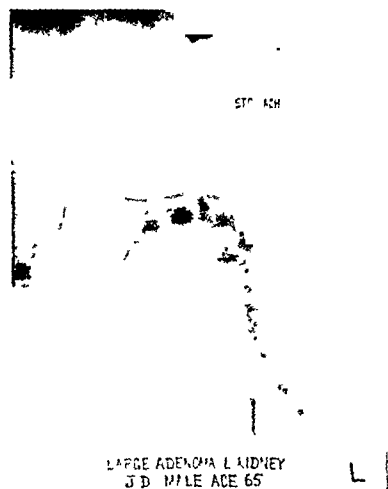


FIG. 247.—Radiograph showing stomach raised by a mass which has also displaced the duodenum and coils of small intestine to the right.

In the case described below, although clinically and macroscopically benign, there is undoubted histological evidence of malignant transformation. For comparison, illustrations and short notes of three other cases are included: (1) A benign papillary adenoma (Prof. Ernest Finch, 1927, *Fig. 253*); (2) A benign cystic adenoma (A. W. Fawcett, 1933, *Fig. 254*); (3) A papillary adenocarcinoma (Prof. Ernest Finch, 1943, *Figs. 255, 256*).

## CASE REPORT

**HISTORY.**—The patient, J. D., male aged 65, a sawyer, complained of a swelling in the left loin and hypogastrium. He had first noticed this swelling



FIG. 248.—Radiograph after barium enema showing pressure defect on the descending colon.

slight frequency during the past year. There was never any blood in the urine. He was admitted to the Victoria Hospital, Worksop, on June 13, 1942.

**ON EXAMINATION.**—Tongue clean and moist, but pyorrhœa present. Heart and lungs apparently normal. There was a cystic swelling palpable in the left loin and left hypogastrium. The swelling could not be pushed forward from the back, owing apparently to its being fixed to the posterior abdominal wall. There was no shifting dullness.

## INVESTIGATIONS.—

June 18: A barium meal showed the stomach raised by a mass, which also displaced the duodenum and upper coils of the jejunum to the right (*Fig. 247*).

June 24: An intravenous pyelogram showed that the left kidney excreted freely and that the pelvis

was dilated and elevated by the mass below. The appearances, however, did not suggest that the mass was renal in origin.

Nothing further was done at the time as the patient elected to go home. He was, however, readmitted on Oct. 2, when the swelling appeared larger.

Oct. 5: A barium enema showed no evidence of any colon neoplasm, but showed a definite pressure defect on the descending colon (Fig. 248). The Kahn test was negative.

**PROVISIONAL DIAGNOSIS.**—A provisional diagnosis of mesenteric cyst was favoured, and a laparotomy was decided upon.

**AT OPERATION (Fig. 249).**—The primary incision was made directly over the centre of the swelling,

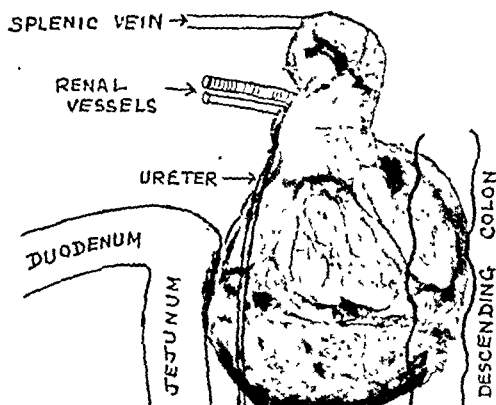


FIG. 249.—Adenoma of lower pole of left kidney as found at operation.

through the left rectus muscle. On opening the peritoneum a large cystic swelling presented. With retraction of the major portion of the cyst, the duodenum was found to be attached to its medial wall. The duodenum was freed from the cyst and retracted. The descending colon, attached to the lateral wall of the cyst, was also freed and retracted. The cyst was then extensively dissected out, and its pedicle, which was extending backwards from the superior surface, was revealed to be the left kidney. During the dissection of the pedicle the splenic vein came into view and was isolated. The kidney and attached tumour were delivered. The ureter was found to be proceeding downwards over the antero-medial surface of the cyst. The left kidney, together with the cyst arising from its lower pole, was removed. Slight oozing of blood in the depths of the cavity was controlled by gauze pressure, and the wound closed without drainage.

Convalescence was uninterrupted, and the patient is in good health 19 months later, and is working 48 hours a week as a sawyer.

**THE SPECIMEN.**—The tumour (Fig. 250), which was oval and flattened anteroposteriorly, was about five times the size of the parent kidney, and together with it weighed 1240 g. It was well encapsulated and attached to the lower pole of the kidney, which was partly replaced by the growth, but separated from it by a thin capsule of condensed renal interstitial tissue. The capsule enveloping the growth was nothing more than the expanded kidney capsule, so that the growth, although apparently external to the kidney, was actually intrarenal.

Spreading radially from the lower pole of the kidney over the anterior surface, and to a less extent over the posterior surface, of the tumour, could be seen numerous dilated veins (Fig. 249).



FIG. 250.—The specimen (for description see text).

Vertical hemisection of the growth showed a central cystic cavity containing fluid, surrounded by a fibrous capsule (Fig. 250). The surrounding solid part of the growth was fleshy, and of the same colour as the substance of the kidney except for scattered areas of hæmorrhage.

**HISTOLOGICAL STRUCTURE.**—The structure as shown by a whole section of a quadrant of the tumour varies from the centre to the periphery.

Centrally it consists of a mixture of tubular adenomatous tissue and thin oedematous vascular

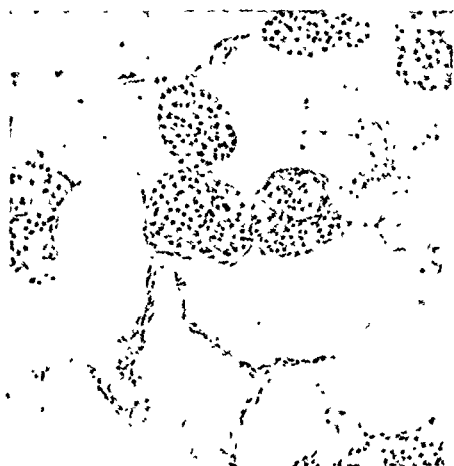


FIG. 251.—Microphotograph of section of centre of tumour, showing adenomatous tubules and fine vascular capillaries.

and even myxomatous connective tissue. This is suggestive of an extension of the degenerative process, which had already led to the formation of the central cystic cavity. The adenomatous tubules here are made up of fairly well differentiated cells closely resembling those of the convoluted tubules, but

because of their neoplastic nature their staining is more basophil, and thus they resemble more the cells of the ascending limb of Henle. These tubules lie coiled up in small, widely separated masses in the



FIG. 252.—Section of tumour towards periphery. (See text.)

neighbourhood of the central cystic cavity, and some appear to lie in a fluid medium which is merely traversed by fine vascular capillaries (Fig. 251).

As the growth is followed towards the periphery the amount of connective tissue decreases, and the tubules become more closely packed, and in some parts of the periphery the growth is distinctly less differentiated and undoubtedly undergoing malignant transformation. The tubular structure is lost, and the cells, varying in size, are arranged in solid masses containing numerous atypical mitoses with monstrous hyperchromatic nuclei (Fig. 252).

The capsule has, however, nowhere been penetrated, and the kidney itself is not invaded, but separated from the growth by a condensed capsule of fibrous tissue.

## DISCUSSION

Ewing (1940) states that transitions from nodular adenomata to infiltrating adenocarcinomata are frequent. There is a continuous series from simple benign growths up to highly cellular and malignant tumours. As malignancy progresses the size of the tumour increases and the encapsulation becomes obliterated. In the case described above, although there is undoubted histological evidence of malignancy, the increase in size has not coincided with invasion and obliteration of the surrounding capsule. Malignant transformation of cystadenomata is described by Klebs (1876), Ziegler (1906), and Ricker (1897). The tumours recorded by them were also of large dimensions and well encapsulated. Progressive growth and malignant transformation of papillary cystadenomata has also been observed by Sturm (1875) and Beneke (1890).

With regard to histological structure it would seem that a progressive degenerative process had been taking place. Centrally the tubules lie

coiled up in widely separated masses with an intervening reticulum of fine vascular capillaries (Fig. 251), whereas in the periphery the tubules are closely packed together with very little intervening connective tissue. Sabourin (1882) quotes cases in which the central portions contained wide tubules becoming cystic, with abundant vascular stroma, and the peripheral portions contained numerous alveoli passing gradually into the surrounding renal tubules.

A review of the literature from the point of view of histogenesis would seem to suggest two lines of thought, first a development from the convoluted tubules of the adult kidney, and secondly a development of a congenital nature.

It has been seen that the adenomatous tubules were made up of fairly well differentiated cells very closely resembling those of the convoluted tubules. Waldeyer (1867), Manasse (1895), and Stoerk (1908) described cases in which the cells resemble those of the convoluted tubules, and claim to have traced growths to these tubules. Stoerk has also traced the development of alveoli from convoluted tubules. In a case of tubular adenocarcinoma quoted by A. Fraser (1914), the growth was large, solid, and circumscribed, with large alveoli and tubules lined by high cubical granular cells. These cells exactly duplicated the cells of the convoluted tubules of the adult kidney.

At first sight (Fig. 250) the growth may appear to be external to the kidney, but on closer inspection it is found to be intrarenal, its capsule being made up of expanded kidney capsule. Luzzato



FIG. 253.—Benign tubular adenoma of right kidney. Clinically: attack of hæmaturia lasting 2 days; palpable right-sided kidney tumour. Left kidney excreted dye normally. Right kidney was removed with some difficulty owing to rotation of the tumour, which might have accounted for the attack of hæmaturia. (Mr. E. Finch's case.)

(1901) and Antona (1900) traced the development of adenomata and adenocarcinomata from pararenal rests. In Antona's case the tumour lay outside the kidney.

The congenital origin is further supported by Ewing's belief that single tumours may be

attributed to localized cicatrices, and that congenital anomalies are probably connected with the cause of tubular adenomata. Nightingale and Lytle (1937) report a case of fibroma of the kidney with cyst in which the cyst was probably produced by obstruction and continued secretion of the tubules in the thinned-out renal tissue forming part of the tumour capsule. Displacement and imperfect development of renal tubules in the renal cortex and capsule has been described by Albarran (1903).

It has been stated that cystadenomata sometimes arise from failure of fusion of the secreting and discharging tubules. Nauwerck and Hufschmidt (1892) and von Kahliden (1894) have pointed out the probable relation between some



FIG. 254.—Congenital cystic adenoma of left kidney. The patient, a trombone player in an orchestra, had felt pain in the left hypochondrium while playing his instrument. Later, on examination, a swelling was palpable; it appeared to be a slightly enlarged kidney which had recently prolapsed. Chromocystoscopy revealed a slightly diminished flow of blue from the left ureter, and the pyelogram showed only two calices and slight distortion of the lower edge of the pelvic shadow.

Exploration revealed a rounded tumour of the kidney in the lower pole and nephrectomy was performed. Longitudinal bisection of the kidney revealed an encapsulated tumour divided into numerous polyhedral spaces containing clear fluid. (Mr. A. W. Fawcett's case.)

cystadenomata and congenital cystic disease of the kidney. The illustration of the congenital cystic adenoma (Fig. 254) definitely tends to support this hypothesis. Keyes (1890) described a case in which the entire kidney was the seat of numerous nodular adenomata, arranged in a manner very suggestive of multiple congenital cysts. The microscopical section of the adenocarcinoma (Fig. 256) shows a very interesting cystic structure, pointing to some possible relationship with congenital cystic disease.

### SUMMARY

A case of tubular adenoma of the kidney with malignant transformation is described.

Illustrations and short notes of a benign papillary adenoma, a benign cystic adenoma, and a papillary adenocarcinoma are included for comparison.

The structure of these tumours is discussed, pointing out the possibility of a continuous series from benign tumours up to highly cellular malignant growths.

The origin of the growths, whether from the convoluted tubules of the adult kidney or from congenital abnormalities, is reviewed.

The pathological illustrations and photographs in this article are the work of Dr. L. C. D. Hermitte, Pathologist, Royal Infirmary, Sheffield.



FIG. 255.—Papillary adenocarcinoma of kidney. For 3 or 4 years the patient had to strain to pass water; for 2 years he had noticed blood in the urine, continuing for 24 hours to 3-4 days at intervals varying between 1 week and 2 months.

Six months ago he had had backache with irritation and scalding on micturition and was unable to pass water for 14 hours; 2 months ago left-sided abdominal pain with vomiting and bleeding per rectum. On examination there was tenderness in the hypogastrium, but no lump was palpable. Kidney not felt, prostate not enlarged. Retrograde pyelography revealed the growth. Nephrectomy.



FIG. 256.—Section of adenocarcinoma in Fig. 255. The cystic structure suggests a possible relationship with congenital cystic disease.

to whom I am most grateful for his very willing co-operation.

I am indebted to Professor Ernest Finch for very kindly undertaking the operative treatment, for his interest in the case, and for allowing me to include his cases of benign papillary adenoma and papillary adenocarcinoma. I also wish to thank Mr. A. W. Fawcett for his permission to include his case of cystic adenoma, which had already been published in this JOURNAL (1933).

## REFERENCES

- ALBARRAN, IMBERT (1903), *Tumeurs du Rein*, 767 (Lit.). Paris.
- ANTONA (1900), *Tumori prim. d. rene.* Rome.
- BENEKE, R. (1890), *Beitr. path. Anat.*, 9, 440.
- EWING, JAMES (1940), *Neoplastic Diseases*, 4th ed., 799. Philadelphia and London: W. B. Saunders Co.
- FAWCETT, A. W. (1933), *Brit. J. Surg.*, 20, 678.
- FRASER, A. (1914), *Trans. N.Y. path. Soc.* 14, 22.
- GORDON-TAYLOR, G. (1930), *Brit. J. Surg.*, 17, 551.
- VON KAHLDEN (1894), *Beitr. path. Anat.*, 15, 626.
- KEYES, SR. (1890), *Amer. J. med. Sci.*, 100, 549.
- KLEBS, E. (1876), *Handbuch der path. Anat.*, Bd. 1, Abt. 2, 617. Berlin.
- LUZZATO (1901), *Riv. vene. Sci. med.*, 34, 395.
- MANASSE (1895), *Virchows Arch.*, 142, 164.
- NAUWERCK, HUFSCHMIDT (1892-3), *Beitr. path. Anat.*, 12, 1.
- NIGHTINGALE, H. J., and LYTLE, S. N. (1937), *Brit. J. Surg.*, 25, 57.
- RICKER, G. (1897), *Zbl. allg. Path.*, 8, 417.
- SABOURIN (1882), *A. de Phys.*, 9, 67.
- STOERK, O. (1908), *Beitr. path. Anat.*, 43, 393.
- (1908), *Berl. klin. Wschr.*, 45, 773.
- STURM (1875), *A. Heilk.*, 16, 216.
- WALDEYER (1867), *Virchows Arch.*, 41, 470.
- ZIEGLER, E. (1906), *Lehrbuch der allg. u. spez. Pathologie*, 5 Aufl., 2. Jena.

## CONGENITAL CYST OF THE COMMON BILE-DUCT CONTAINING STONES AND UNDERGOING CANCEROUS CHANGE

By S. T. IRWIN

SURGEON, ROYAL VICTORIA HOSPITAL, BELFAST

AND J. E. MORISON

ASSISTANT PATHOLOGIST, ROYAL VICTORIA HOSPITAL, BELFAST

A LARGE cyst of the common bile-duct is a pathological rarity which demands a record. The present case was of additional interest in that it contained gall-stones and that the lining of the cyst had undergone carcinomatous change. Furthermore, in spite of gross dilatation of the common duct, the hepatic and cystic ducts and the gall-bladder showed no evidence of disease or distension.

### CASE REPORT

**HISTORY.**—J. M., aged 30 years, a prison warder, was admitted to the Royal Victoria Hospital on Sept. 8, 1941, with a history of severe upper abdominal pain, suggestive of gall-stones. The patient had had three attacks of pain of similar type within a few weeks, following one of which he was in a country hospital for twenty-one days.

**ON ADMISSION.**—He was a robust, rather stout male without obvious cyanosis, jaundice, or anaemia. He was complaining of pain in the upper abdomen. On palpation there was general rigidity in the epigastric region and in the right iliac fossa, with slight tenderness over the gall-bladder. As the diagnosis was obscure and as a diagnosis of gall-stones had been made by his medical attendant, it was thought desirable to do a cholecystogram. The report of this examination was: (1) In the straight picture there is no evidence of gall-stones. (2) The cholecystogram shows a normally filling gall-bladder.

Other examination was negative, except that his urine had a specific gravity of 1038 and a trace of sugar.

After being in hospital for a few days with tenderness persisting in the right iliac fossa, a tentative diagnosis of appendicitis was made.

**1ST OPERATION.**—The Resident Surgical Officer operated on Sept. 15 through a gridiron incision. The appendix was oedematous, but did not contain pus and was not necrotic. It was regarded as being pathological. The gall-bladder and duodenum were palpated through the abdominal wound and were considered to be normal.

**PROGRESS.**—The patient left hospital ten days after the operation and for a month remained well. The upper abdominal pain then recurred and he

was readmitted to hospital on Dec. 12, 1942, with the history that after several attacks of moderate severity he became jaundiced for the first time on Dec. 6. The pain was more severe than formerly and began to radiate towards the right shoulder. Examination at this time revealed slight jaundice with tenderness in the epigastrium and under the right costal margin. Murphy's sign was now positive and the liver was noticeably enlarged.

**2ND OPERATION (S.T.I.).**—This was performed on Dec. 15, a general inhalation anaesthetic being administered by Dr. Stafford Geddes. On opening the abdomen through a right rectus incision some blood was found free in the peritoneal cavity. The gall-bladder was somewhat distended and the liver grossly enlarged and tense. There was a large tumour, about the size of a closed fist, in the region of the head of the pancreas. On palpation this was craggy at the edges but cystic in the centre. The cystic cavity was aspirated and found to contain viscid green bile. The cyst was therefore opened and large quantities of bile exuded, as well as several moderate-sized gall-stones. Lining the inner surface of the cavity there were sessile patches of growth, one of which was dissected off for microscopical examination. A rubber tube was sewn into the opening in the common bile-duct and brought out through a stab wound in the right side. The gall-bladder was anastomosed to the stomach.

The operation was considerably hampered by free bleeding from the liver substance. This was produced by the gentlest handling of the organ and during the operation several points had to be closed by suture.

The operation throughout was accompanied by shock due partly to the amount of haemorrhage from the liver and partly to the difficulty in maintaining a sufficient depth of anaesthesia. The shock was unrelieved by blood transfusion followed by intravenous infusion of glucose saline and the patient succumbed within twenty-four hours.

**PATHOLOGICAL REPORT (J. E. M.).**—The post-mortem examination had to be limited to the abdomen. The liver, its ducts, the stomach, duodenum, and pancreas were all removed together and, after fixation and some inevitable shrinkage of the hollow viscera,

the specimen shown in Fig. 257 was prepared. The hepatic duct and the cystic duct, neither of which was more patent than normal, opened into the upper end of the dilated portion of the common bile-duct at a distance from each other of 2 cm. This part of the duct lay behind the first part of the duodenum and



FIG. 257—The liver and biliary passages. The pancreas and attached structures have been rotated to the left through almost a right angle to bring them into the antero-posterior plane of section of the liver. A, Gall-bladder; B, Common hepatic duct; C, Opening of cystic duct; D, Elevated tumour mass; E, Site of ampulla of Vater.

to the right of the other structures of the lesser omentum. Though it reached to within 2.5 cm. of the ampulla of Vater no connexion could be established between the lower end of the duct and the duodenum, and it is uncertain whether this point represented the lower opening of the cyst. This occlusion of the lower opening from the dilatation was due to the invasion of the wall by white tumour tissue, which at one point on the right posterolateral wall projected slightly as a flat, red area 3 cm. in diameter. From this it had infiltrated the wall of a large part of the dilated duct and, spreading through the pancreas, had invaded the retropancreatic lymph-nodes. At post-mortem the cystic cavity contained a few small pigmented calculi, some amorphous debris, and a little watery bile. The gall-bladder had been anastomosed to the stomach and the junction was perfect, and the viscus itself contained no calculi and was not dilated.

*Histological examination* showed that the white tissue infiltrating the wall of the cyst was a squamous carcinoma with occasional areas of keratinization and small, ill-defined cell-nests. The invasion of the wall of the dilated portion of the duct was even more widespread than naked-eye examination suggested, and the growth had arisen in the duct and showed only a slight and localized invasion of the pancreas with more extensive infiltration of the retropancreatic lymph-nodes. This invasion did not extend upwards as far as the entrance of the cystic or hepatic ducts

and here the wall was composed of fibrous tissue infiltrated by small mononuclear leucocytes and the covering epithelial cells were deficient. There was no fibrosis of the gall-bladder wall and apart from some increase of mucin-secreting cells this viscus was normal and the cholecyst-gastrostomy junction was remarkably free from inflammatory change. There was no dilatation of the intrahepatic bile channels and no accumulation of bile-pigment in the liver or increase of mononuclear cells in the portal tracts. Detailed microscopical examination of the other abdominal organs revealed no features of relevant interest.

### COMMENTARY

Detailed examination has excluded a primary pancreatic growth, but it may be suggested that the condition is a primary squamous carcinoma occurring in a previously normal common bile-duct. The widespread distribution of the tumour and its apparent site of origin on the right posterolateral wall would require dilatation of the duct of long duration. The short history of biliary obstruction and the remarkable absence of dilatation of either the cystic or hepatic ducts makes it difficult to believe that such a dilatation could follow the occlusion of the lower end of the duct by the tumour.

Blockage of the lower end of the common bile-duct by a stone and subsequent, or simultaneous, development of a carcinoma requires that a stone should form in an otherwise normal gall-bladder, which now contains no calculi, and that the stone should pass down the cystic duct without producing any distinctive symptoms.

It is suggested that the remarkable dilatation of a part of the common bile-duct and the equally impressive absence of dilatation in the hepatic and cystic ducts are due to an idiopathic choledochus cyst, which has probably existed from an early age. In spite of the views of many writers, it seems impossible that intermittent kinking or obstruction of the lower end of the duct alone could produce such a localized dilatation of the biliary system and some localized congenital deficiency or weakness of the wall seems necessary. This is supported by the findings of Heiliger of a diverticulum in an almost mature foetus and by Walton's sixth case in which there was a sacular dilatation in a 5-weeks-old infant. After a number of years and from the irritation of stagnating bile, the epithelium lining the cyst in the present case may have undergone patchy squamous metaplasia, and later this gave rise to a squamous carcinoma.

In almost all the cases described the epithelial lining has been deficient in the specimens obtained. The few small calculi noted were also probably formed here and not in the gall-bladder. Partial obstruction by these calculi, or interference with the emptying of the cyst by the extension of the carcinoma, may explain the attacks of right-sided abdominal pain, but the development of jaundice only nine days before death was more probably due to closure of the duct by the growth of the neoplasm.

The relatively early age of onset of the carcinoma may stimulate speculation as to the possible carcinogenic influence of bile acting on an altered epithelial surface. The close chemical relationship of bile acids and methyl-cholantrene, probably the most active carcinogenic agent known, may be recalled.

**A Squamous Carcinoma in an Idiopathic Choledochus Cyst.**—The condition of congenital diverticulum, cyst of the common bile-duct, or choledochus cyst has been the subject of numerous case reports. These are mostly concerned with single cases and are adequately reviewed by Walton (1939). He was able to report 6 new cases, and reports of almost 100 cases must now be accepted. No report of a neoplasm supervening in such a cyst has been discovered.

## SUMMARY

1. A large cyst of the common bile-duct is recorded.

2. Diagnosis was not effected by clinical examination, by a cholecystogram, or by palpation of the gall-bladder region through a lower abdominal incision.

3. The cyst contained gall-stones and had undergone carcinomatous change.

4. In spite of the large size of the cyst and the presence of jaundice, the gall-bladder and the hepatic and cystic ducts were not dilated.

## REFERENCE

WALTON, J. (1939), *Brit. J. Surg.*, 27, 295.

## SHORT NOTES OF RARE OR OBSCURE CASES

### AN UNUSUAL TYPE OF ARTERIOVENOUS COMMUNICATION

By J. R. LEARMONTH, EDINBURGH

#### CASE REPORT

**HISTORY.**—On June 17, 1943, Flight-Sgt. R. W. W., aged 43, was on a range when a grenade exploded in the air about 1 yd. in front of his face. He received scattered multiple wounds, 43 in all. He did not lose consciousness, but felt a pain "like a saw" in the left side of the neck, and bent his head to the left to relieve it. Profuse arterial bleeding occurred from a wound of the left side of the neck, and it was noted that the left superficial temporal pulse could not be felt, whereas the right was normal; the hæmorrhage was controlled by sustained direct pressure applied to the small puncture in the neck, and he was taken to hospital. Here one pint of plasma was given. On June 18 it was noted that a thrill was present over the left common carotid, and on June 21 that the left pupil was smaller than the right.

On July 10 I saw him through the kindness of the late Mr. Pirie Watson. At this time his wounds were healed, but he complained (1) of a feeling of giddiness when he sat up in bed for any length of time; (2) of a continuous "buzzing" in the left side of the neck, which he noticed for the first time two days after the accident; (3) of a continuous "buzzing" in the left ear when he turned his head to the left; (4) of the pressure of "a little lump" interfering with swallowing, when he turned his head to the right; and (5) of pain and paraesthesia in the medial side of the left forearm and in the 5th finger.

**ON EXAMINATION.**—He was a good witness, though somewhat emotional and inclined to be tearful, a point which impressed us because he had previously been awarded the George Medal.

**Cardiovascular System:** Over the anterior border of the left sternomastoid muscle, 2 cm. above the clavicle, there was a small healed wound. Under this lay a pulsatile swelling, oval in shape, and measuring 4.5 by 3 cm. There was a marked thrill, and on auscultation a blowing murmur, loudest 3 cm. above the clavicle and 2 cm. lateral to the medial border of the sternomastoid. The superficial temporal and radial pulses were equally palpable on both sides. In

both arms the blood-pressure was 110/60. The heart was normal in size; over it there were heard in all areas, but loudest in the aortic and pulmonary, blowing systolic and diastolic murmurs.

A radiograph showed numerous small fragments of the grenade in the soft tissues.

**Eyes:** The left pupil was much smaller than right, but both reacted to light and on accommodation.



FIG. 258—Elevation and section of the arrangement of the vessels contributing to the arteriovenous communication.

In consultation with Brigadier Anderson, Consulting Surgeon to the Scottish Command, it was agreed that the fistula should be explored; and Brigadier Anderson very kindly gave his advice and his assistance at the following operation.

**AT OPERATION (July 18).**—Pentothal for intubation, followed by intratracheal gas-oxygen-ether (Dr. Hales). Incisions were made: (1) from angle of jaw, along anterior border of sternomastoid beyond sternal notch; and (2) from the first incision 2 cm. above clavicle, laterally to the anterior border of trapezius. A triangular flap of skin and platysma was reflected laterally, the sternomastoid divided close to the



clavicle, and also reflected laterally. The internal jugular vein could be seen to pulsate. At the upper end of the field the common artery was isolated and controlled by a tape, and the internal jugular vein by two catgut ligatures (after ligature and division

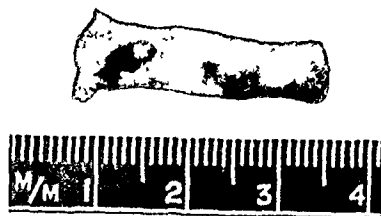


FIG. 259.—The opening in the common carotid artery.

of the common facial vein); and a similar temporary control of the vessels was established low in the neck.

The proximal tape on the common carotid was then tightened to occlude the artery. Contrary to expectation, the swelling on the internal jugular vein continued to pulsate. Under the impression that the carotid was not implicated, I separated the internal jugular vein from it; this was followed by sharp bleeding, controlled by local pressure; and when the field was clear I found a hole in the posterolateral wall of the carotid, measuring (after fixation) 0.7 cm. by 0.3 cm., and a corresponding opening in the internal jugular vein (Figs. 259, 260). The common carotid was now tied with silk close to its bifurcation, and proximal to the fistula, and the intervening segment was removed. The internal jugular vein was divided between ligatures in the upper part of the wound. It

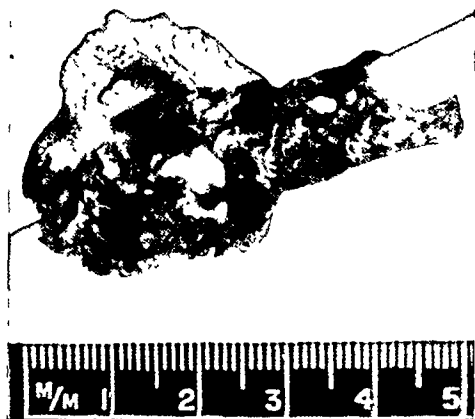


FIG. 260.—Medial aspect of internal jugular vein, showing (1) the direct communication with the common carotid artery, (2) (above left) the false sac, with (3) the opening communicating with the vertebral artery.

was clear that a second arterial communication with the internal jugular vein must be present, and that it must involve either the inferior thyroid artery or the vertebral artery. While the opening in the vein was controlled by finger pressure, the phrenic nerve was identified and retracted, and the omohyoid and scalenus anterior muscles divided to expose the second and first parts of the subclavian artery. The thyroid axis was

then ligatured, close to the subclavian; the pulsation in the vein persisted, and it was clear that the second communication was with the vertebral artery (Fig. 260). This artery was clamped close to the subclavian; pulsation in the vein ceased at once, and after the controlling finger was removed there was no bleeding for 30 seconds, when it began again in a continuous flow, although arterial in appearance. This was thought to be from the cranial segment of the vertebral artery. A finger was placed so as to control bleeding from the vein, which was then gradually dissected towards the median line. During this stage it was seen that the vagus had been included in the provisional ligature at the cardiac end of the internal jugular vein; it was freed, and the vein divided between two silk ligatures. The isolated segment of vein was then dissected medially, when a pouch-like process was identified behind it, which proved to be the sac of an aneurysmal varix (Fig. 261). Two large lymph-vessels blending with the sac wall were ligatured and divided, and the sac was cleared off the anterior aspect of the transverse processes. Cautious removal of the finger-tip now showed steady but arterial bleeding from a slit-like opening communicating with the vertebral artery in tough fibrous tissue between the 5th and 6th transverse processes. The clamp on the origin of the vertebral artery was now replaced by a ligature, and silk ligatures on needles were passed above and below the opening in the artery, through the fibrous tissue and so as to include the vessel. All bleeding was now controlled. The sternomastoid was sutured to its origin and the incision closed save for the exit of a soft rubber drain down to the dome of the pleura. The patient stood the operation well; during its closing stages a transfusion of 1 pint of blood was given. Throughout the operation the blood-pressure and pulse-rate were recorded by Dr. R. L. Richards: these did not change significantly at any of the ligations.

PROGRESS.—The patient made a good convalescence, and there was never any evidence of cerebral

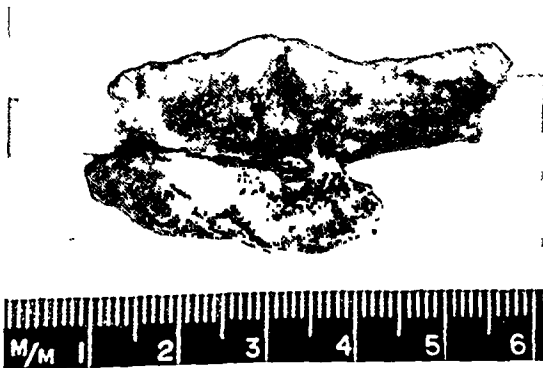


FIG. 261.—Lateral aspect of internal jugular vein, showing the false sac behind it.

ischaemia. He was kept flat till July 23, when blocks were put at the head of the bed. By Aug. 4 he began to sit up; on Aug. 8 he was out of bed, but complained of headache on the right side. On Aug. 11 Major Porter, R.A.M.C., the Command Neurologist, kindly examined him and reported: "This N.C.O. complains of a continuous heavy sensation over the right side of his head. He says that this side of his head feels 'warmer' than the left. No real pain and

no throb. Left side of his head he says feels 'clear'. He has been hoarse since the operation, but there is no subjective evidence of dysphasia either receptive or expressive. He says that since the explosion his hearing has been poor, he has noticed difficulty in hearing the news on the wireless and often misses what the nurses say to him and has to ask them to repeat it. His ears feel 'full'. No visual disturbance. No diplopia. No weakness or clumsiness of limbs. No numbness or tingling.

"C.N.S.—Optic discs normal. There is a small patch of pigmentation about 1 disc diameter from the disc in the left fundus at 7 o'clock. Retinal vessels are normal. Visual fields full to careful confrontation. He has a left Horner syndrome with moderate ptosis and a small pupil on the left side. Both pupils react briskly to direct and consensual light and react well on convergence. External ocular movements are full. There is fine sustained nystagmus on extreme lateral deviation to left and right. No vertical nystagmus. No sensory abnormality of the face. Corneal reflexes brisk and equal. Paralysis of retraction of the left lower lip. Other facial movements are good and equal. In ordinary conversation he heard everything I said in a low voice and there did not appear to be any deafness. On testing with a watch, however, he heard my watch 2 in. from his ear on both sides (normal about 6 in.). There appears, therefore, to be slight bilateral deafness. Not tested with tuning-fork.

"Motor.—He has generalized wasting. *Upper limbs*: No localized wasting or weakness. No dystonia or ataxia. No clumsiness of fine finger movements. *Lower limbs*: No localized wasting or weakness. No dystonia or ataxia. Biceps and triceps

jerks present and equal, knee and ankle jerks present and equal. Plantar response bilaterally flexor. No cutaneous analgesia or anaesthesia. Postural sense normal. Vibratory sense normal. Two-point discrimination normal in finger-tips. No astereognosis. He has (1) a left cervical sympathetic palsy, (2) a lesion of the left cervical branch of the facial, and (3) a lesion of the left recurrent laryngeal nerve due to involvement in the neck. Examination of the nervous system apart from this is completely negative except for the fine nystagmus on lateral deviation to right and left which I do not think indicates a central lesion and is more probably secondary to the aural condition in view of the bilateral slight deafness and sensation of fullness which he has had in his ears since the explosion. I can find no physical evidence of impairment of function of the C.N.S."

The patient was discharged to a convalescent home on Aug. 31. He returned on Sept. 14, feeling much better and looking more cheerful; and later returned to civil life, where he has remained well.

Recently (August, 1944) he was seen by Professor Geoffrey Jefferson, of Manchester, who informed me that he has remained well and is at light work.

### COMMENT

I have been unable to find any other record of a lesion in which two arteries contributed to an arteriovenous fistula. It is also of interest that this patient of 43 was not affected by the complete interruption of the direct arterial supply to one side of the brain.

## A LARGE VESICAL CALCULUS PASSED PER (FEMALE) URETHRAM

By McNEILL LOVE

SURGEON, ROYAL NORTHERN HOSPITAL, LONDON

REFERENCES in literature to the spontaneous passage of calculi by way of the female urethra are very scanty, but in 1869 Bourdillat, of Paris, collected a number of cases. These included one in which a woman passed two calculi weighing 40 g. and 105 g. respectively, and another recorded that a girl of 18 passed a calculus weighing 4 oz., which resulted in a urethro-vaginal fistula.

Vesical calculi in females are usually due to the introduction of foreign bodies into the bladder. These include a strange assortment of articles, among which are nails, hairpins, wire, stalks of grass, pencils, and, most common of all, pieces of slippery elm. In the majority of cases the article is introduced in a misplaced attempt to procure abortion. The foreign body is sooner or later coated with phosphates, consequent on secondary cystitis. The specimen described herewith\* is unusual in that it is a primary oxalate calculus (in most cases primary calculi are extruded when they are small in size). The measurements of the stone are: circumference, maximum  $5\frac{3}{8}$  in., minimum  $4\frac{5}{8}$  in.; diameter, maximum  $1\frac{3}{4}$  in., minimum  $1\frac{1}{8}$  in. (Fig. 262). It is a remarkable tribute to

the ability of the female urethra to dilate that a stone of this size could negotiate the passage without causing more than temporary disability.

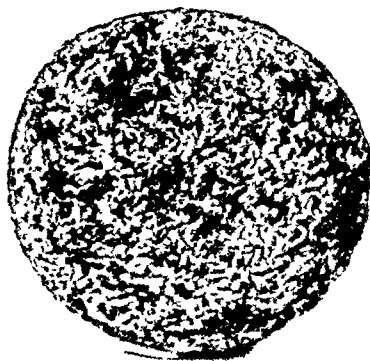


Fig. 262.—Photograph of calculus. (Actual size.)

The history of the specimen is of some interest, as the patient was referred to hospital by her medical practitioner as a "woman in labour". She was the mother of four children,

\* Demonstrated at the Medical Society of London, Jan. 10, 1944.

and was nearing the climacteric, with consequent derangement of the menstrual rhythm. She had noticed frequency of micturition for some months, and more recently had suffered from abdominal pain and discomfort. She therefore consulted her doctor. Abdominal examination revealed a swelling reaching to well above the umbilicus (which was the bladder). On vaginal investigation he felt a hard swelling, which he considered to be the foetal head (but this was the stone in the urethra). Believing the patient to be in labour, he arranged for her transport to hospital. On admission, further investigation revealed the true state of affairs. With the aid of morphia, atropine, and a hot bath, the stone

passed naturally. Incontinence of urine followed, but control was regained in about twelve months. Curiously enough, the patient did her best to exonerate the doctor for his erroneous diagnosis of pregnancy, for she volunteered the statement that, during the passage of the stone, "she felt as though she was giving birth to a hedgehog!"

Dr. Cuthbert Dukes kindly bisected the stone and analysed its composition. He reports that there is no evidence of any foreign body, and that it is composed of calcium oxalate with a small amount of blood-pigment.

#### REFERENCE

BOURDILLAT (1869), *Calculs de l'Urèthre*. Paris.

## AN UNUSUALLY LARGE LIPOMA

By N. DUGGAN

HON. SURGEON, WORCESTER ROYAL INFIRMARY

EVERY surgeon of experience has met with examples of large lipomata, but the case illustrated is possibly unique.

### CASE REPORT

The patient, a healthy agricultural labourer, aged 56, and unmarried, presented himself at the hospital, not because of his immense burden, but from alarm at a slight hæmorrhage from a dilated vein at the dependent part of the tumour.

burden with stoical good humour. While at work he contrived to support the weight by a strong belt.

The tumour hung from the neck by a pedicle the thickness of his arm. The skin over the dependent part was thickened and rough, with numerous large and tortuous veins coursing over the surface, one of which had ruptured on the day of admission. Bleeding was not severe, and ceased when he was put to bed.

Operation for removal of the tumour proved simple, as the pedicle consisted only of skin and



FIG. 263.—Photographs showing the immense size of the tumour.

He had first noticed a lump at the right side of his neck about twenty-six years ago. This grew quietly and painlessly until the last four years, when the increasing weight caused it to become pendulous. Growth thereafter was more rapid, until the fantastic size shown in the illustration was reached (Fig. 263).

He had worked regularly as an agricultural labourer until the day of admission to hospital, bearing his

hypertrophied platysma, with a few large vessels easily controlled.

Effective sterilization of the skin was impossible, as the back of the pedicle was rough and ingrained with many years' accumulation of dirt and sweat, but a thorough dusting of the wound with sulphanilamide powder resulted in uneventful primary healing.

The tumour weighed 24 lb. 7 oz.

## A CASE OF INTRAMURAL ABSCESS OF THE COLON

By FRANCIS E. STOCK

MEDICAL OFFICER, COLONIAL MEDICAL SERVICE, NIGERIA

## CASE REPORT

**HISTORY.**—A male Ibo native, aged about 25 years, was admitted to the African Hospital at Jos on Dec. 17, 1942, complaining of acute pain in the right iliac fossa for three days. The onset had been gradual but the pain had rapidly increased in severity. There was no history of central abdominal pain. He had not vomited, his bowels were open normally, his appetite was normal, and there were no other symptoms.

**ON EXAMINATION.**—His temperature was 98.6° F.; pulse 76, and of good volume. The tongue was clean. The abdomen was not distended. There was very great tenderness and some rigidity in the right lower abdomen and this was most pronounced at a point about 1 in. above McBurney's point. In this situation a lump about the size of a hen's egg could be felt. It was not movable and was extremely tender to touch. Nothing abnormal could be detected on rectal examination. The diagnosis was in doubt, beyond the fact that an acute abdominal condition was present, probably of an inflammatory nature. Everything pointed against acute appendicitis, with or without abscess formation. It was decided to perform a laparotomy.

**AT OPERATION.**—The abdomen was opened under chloroform anaesthesia, by a right paramedian incision. The appendix was at once seen to be normal. There was considerable injection of the anterior wall of the ascending colon about 2 in. above the ileocaecal valve, where a hard lump could be felt. Enlarged glands could also be felt in the mesentery. It was then considered that the most likely diagnosis was localized tuberculosis of the ascending colon, and in view of the small area affected, an excision of the terminal ileum, caecum, and ascending colon was performed. There was no particular difficulty in this procedure, although in the region of the mass, the ascending colon was very adherent to the posterior abdominal wall. Continuity of the bowel was restored by side-to-side anastomosis.

Recovery was uneventful and the patient was discharged on the eighteenth day after operation.

**THE SPECIMEN.**—There was a mass 1½ in. in diameter in the anterolateral wall of the ascending colon. No tubercles were seen on the peritoneal surface, which was, however, very inflamed. On opening the bowel, the mucous membrane was found to be entirely normal and there was no evidence of any inflammation or ulceration which might have resulted from tuberculous infection, dysentery, or infection with *Schistosoma mansoni*. The swelling which could be felt in the lateral wall bulged into the lumen. An incision was then made into the swelling (Fig. 264). The bowel wall was grossly thickened and in the centre of the mass of inflammatory tissue was a small abscess cavity filled with greenish pus. A smear of the pus showed pus cells, cellular debris, but no organisms. Microscopical examination of the wall of the abscess cavity showed normal inflammatory tissue, with here and there large masses of eosinophils, which appeared to suggest a parasitic aetiology.

**Discussion.**—Cases of this nature are very rare and in this instance there was no evidence as to its causation. Examination of the faeces made after the operation showed no evidence of intestinal schistosomiasis, which might conceivably have been responsible for the abscess. There



FIG. 264 —The macroscopical appearance of the ascending colon, showing the gross thickening of the wall and the small central abscess cavity.

was, however, no evidence of this in the macroscopical or microscopical appearance of the bowel wall. It is therefore suggested that this case may represent an early stage in the condition of regional ileitis, although the disease was not present in the terminal ileum.

I am indebted to the late Dr. E. C. Smith for the microscopical report on the specimen; to Mr. J. E. Knight for the photograph; and to the Honourable the Director of Medical Services of Nigeria for permission to publish this report.

## A FILARIAL NODULE SIMULATING A CYST OF THE EXTERNAL SEMILUNAR CARTILAGE

By J. A. W. BINGHAM, MAJOR, I.A.M.C.,  
AND STUART McDONALD, JUN., MAJOR, R.A.M.C.

FROM A MILITARY LABORATORY, INDIA

### CASE REPORT

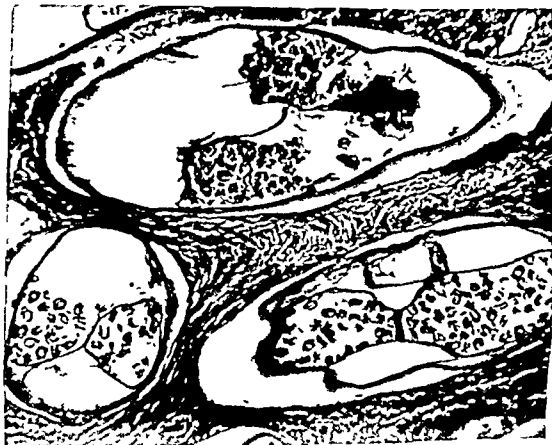
**CLINICAL HISTORY.**—The patient, Gnr. N. M., West African Forces, aged 23, was admitted to an Indian Base Military Hospital on July 27, 1943, suffering from a metatarsal fracture. While in hospital he complained of pain in the outside of the left knee, which had been present for about four months and which was aggravated by marching.

**ON EXAMINATION.**—There was a small rounded swelling slightly cystic in consistency, over the middle of the outer side of the left knee and exactly over the

in diameter, which were enmeshed in a highly cellular connective-tissue stroma. These structures had a doubly contoured hyaline wall and contained innumerable non-sheathed larvæ, averaging  $140 \times 5$  microns (Fig. 265); they clearly represented the cross-sections of several filarial worms. In many instances the worm sections were degenerate and showed early calcification. The remainder of the lesion had the structure of dense granulation tissue in which were scattered small numbers of entire worm sections together with numerous free microfilaria. This granulation tissue was moderately vascular and was



A



B

FIG. 265.—Sections through filarial nodule. A, Low power; B, High power.

joint line—clinically, a typical cyst of the external semilunar cartilage. It was slightly tender on palpation. There was no effusion in the joint and neither ligamentous laxity nor limitation of movement was present. There were no other nodules on the surface of the body.

**OPERATION.**—On March 9, under spinal anaesthesia, the joint was opened to the outer side of the ligamentum patellæ. The external semilunar cartilage was seen to have an extensive peripheral detachment and was unconnected with the swelling on the outer side of the joint. The cartilage was removed. The swelling was then exposed by continuing the skin incision backwards and incising the joint capsule immediately over it. The lesion was found to consist of an easily enucleable, rather friable nodule about the size of a hazel-nut, lying in the extrasynovial fat between the joint capsule and the synovial membrane. This nodule was removed and the incision sutured. Post-operative progress was satisfactory and the patient was transferred to another hospital on Oct. 11.

**HISTOLOGICAL EXAMINATION OF NODULE.**—The larger part of the specimen consisted of about 130 round or oval structures, averaging about 0.29 mm.

characterized by the presence of proliferating fibroblasts and swollen granular macrophages, together with lymphocytes and plasma cells. In some areas there were numerous neutrophil and a few eosinophil granulocytes. Occasional groups of degenerate fibres were present; these may possibly have been portions of the tendinous insertion of the popliteus. The entire lesion was limited by a rather ill-defined fibrous capsule.

Exact identification of the species is not possible in paraffin sections. From the clinical manifestations of the case, the parasite may be presumed to be *Onchocerca volvulus*, since neither *F. loa* nor *W. bancrofti* produce fibrous nodules. Following the histological diagnosis, attempts to demonstrate microfilaria in the patient's blood proved negative; this supports the diagnosis of *O. volvulus* infection.

### DISCUSSION

It has been asserted that there is no other condition presenting the same clinical picture as a cyst of the external semilunar cartilage. Watson-Jones (1943) states that a cartilage cyst

"is the only tense swelling which is situated exactly in the middle of the lateral surface of the knee at the level of the joint line". According to Romanis and Mitchiner (1934), cartilage cysts "are the only form of cyst which actually occurs on the joint line".

At present, when many surgeons are working for the first time in the tropics, it would seem worth while to emphasize the occurrence of parasitic lesions of the knee-joint. Onchocercic nodules are unlikely to occur except in natives of West Africa and South America, and from the literature at our disposal it would appear that the case we have described is the first record of an onchocercic nodule occurring deep to the capsule of a joint. Manson Bahr (1942, a) describes these nodules as typically subcutaneous, but quotes Déjou as having recorded onchocercic nodules in French West Africans, microfilariae being present in the synovial fluid. In addition to onchocerciasis, the possibility of guinea-worm invasion

of the knee-joint should be entertained. Manson-Bahr (1942, b) describes calcified guinea-worms within the joint and Chaudhari (1944) has recorded a case where this gave rise to a mistaken diagnosis of cartilage cyst.

We are indebted to Colonel W. E. Rees-Williams, O.B.E., I.M.S., and to Lt.-Colonel R. N. Phease, R.A.M.C., for permission to publish the case, and to Lt.-Colonel S. Sokey, I.M.S., for the microphotograph.

#### REFERENCES

- CHAUDHARI, A. M. (1944), personal communication.  
 MANSON-BAHR, P. (1942, a), *Manson's Tropical Diseases*, 11th ed., 783-784. London: Cassel.  
 — (1942, b), *Ibid.*, 793.  
 ROMANIS, W. H. C., and MITCHINER, P. H. (1934), *Science and Practice of Surgery*, 504. London.  
 WATSON-JONES, R. (1943), *Fractures and Joint Injuries*, 3rd ed., 721. Edinburgh: E. & S. Livingstone.

## FOREIGN-BODY CYST OF TRICEPS MUSCLE

By J. GUNN ROBERTS

ASSISTANT, SURGICAL UNIT, WELSH NATIONAL SCHOOL OF MEDICINE, CARDIFF

### CASE REPORT

**HISTORY.**—A miner, S. E., aged 37, when seen at the Surgical Out-patient Department, complained of a swelling of the upper part of the left arm which he had first noticed following an accident in the nature of a strain sustained at the coal face eight months previously. Since then the swelling had not altered in size and, apart from an occasional shooting pain down the left arm, he had been symptom free. Later, after operation, he volunteered the further information that in 1922 while working in a quarry an explosion took place prematurely and he was struck on the left shoulder by several pieces of stone which produced a deep wound on the back of his arm just below the tip of the shoulder. The wound healed in two weeks' time and he thought no more about it.

**ON EXAMINATION.**—A soft, fluctuant, non-transilluminable tumour, 4 in. by 3 in., was felt on the postero-lateral aspect of the left upper arm: it was not attached to the skin, but was fixed deeply to the upper fibres of the triceps muscle. A healed scar was seen in the skin 1½ in. above the upper pole of the swelling. The provisional diagnosis of an intramuscular lipoma was made.

**OPERATION** (April 9, 1943).—An encapsulated cystic tumour was dissected with difficulty out of the upper part of the triceps muscle, to which it was adherent; the superior pole of the tumour was continuous with a mass of dense fibrous tissue containing calcified nodules which extended upwards and backwards in the substance of the triceps under the posterior border of the deltoid muscle. The tract was excised as far as the deltoid, where it disappeared into the depths of that muscle.

**THE SPECIMEN** (Fig. 266).—A cystic tumour 2½ in. by 1½ in., with a thin wall 2 mm. thick, containing a thick yellow grumous material and at its lower

end three smooth stones, the largest of which measured ½ in. by ¼ in. At the upper pole of the tumour was a tract of fibrous tissue.

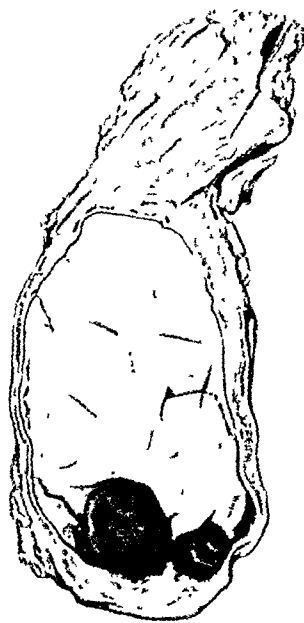


FIG. 266.—Foreign-body cyst after removal. ( $\times 2$ )

**HISTOLOGICAL REPORT** (Dr. Jethro Gough).—The cyst wall is composed of fibrous tissue with a lining of striking appearance. It has an epithelium-like

structure and is composed of elongated cells set in palisade fashion. It has no resemblance to squamous epithelium and is presumably composed of cells of endothelial origin, as the appearance is not unlike that seen in cysts of synovial membranes. Immediately outside the lining the fibrous tissue is of more



FIG 267.—Microscopic appearance of cyst wall. ( $\times 100$ )

loose arrangement, but it is more dense peripherally. There are collections of lymphocytes, especially around the vessels, and scattered throughout the tissue are phagocytic cells containing brown haemoglobin-derived pigment. There are numerous multinucleated foreign body giant cells in the wall, most numerous towards the interior. (Fig. 267.)

### DISCUSSION

The reaction of the tissues to the continued presence of a foreign body was described by Salzer (1908) in his lecture to the New Sydenham Society. Foreign bodies either produced no perceptible reaction or they became encapsulated. As a result of the encapsulating process the foreign body was either: (1) completely enclosed by an intense fibrous tissue overgrowth; or (2) a large amount of serous fluid was found between the connective-tissue capsule and the foreign body, resulting in the formation of a 'foreign-body cyst'. This later occurrence was very rare and Salzer could only report 2 cases:—

*Billroth's Case.*—A thin-walled cyst containing a piece of glass was removed from the arm in the region of the elbow-joint.

*Salzer's Case.*—A large cyst the size of a hen's egg containing a bullet was dissected out of the palm of the hand seven years following an accident.

In both these cases the foreign body was completely encapsulated and the wall of the cyst was composed of fibrous tissue arranged concentrically with an inner lining of endothelial cells.

The contents of the cysts described have in the majority of cases been of thick yellowish grumous nature, though Tees (1919) reported a foreign-body cyst containing gas and a small amount of serous fluid, the foreign body being a corroded aluminium bullet. In Thompson's case (1944) the cyst, in addition to containing thick grumous material, also contained pus.

Two cases of foreign-body cyst have been reported where the foreign body was partly in the cyst and partly out of the cyst. Christie (1932) described a large cyst of the buttock into which the point of a bone knitting needle  $4\frac{1}{2}$  in. long was found projecting, and Thompson (1944) found a cyst in the sole of the foot into which a thorn  $1\frac{1}{2}$  in. long protruded. Various types of foreign bodies have been reported as the cause of foreign-body cysts: Bullets (Salzer, 1908; Tees, 1919), glass (Billroth), bone needle (Christie, 1932), and a thorn (Thompson, 1944).

### SUMMARY

A case of foreign-body cyst of the triceps muscle produced by three small quarry stones is described. The cyst was removed 22 years after the initial accident. Similar cases reported in the literature are discussed.

I am indebted to Professor J. B. Duguid and Dr. Jethro Gough of the Pathology Department of the Welsh National School of Medicine for the histological report and the microphotograph

### REFERENCES

- CHRISTIE, G. W. (1932), *Brit. med. J.*, **1**, 1031.  
 SALZER (1908), *New Sydenham Society Lectures*, **148**, 109. London.  
 TEES, F. (1919), *Brit. J. Surg.*, **7**, 293.  
 THOMPSON, J. F. (1944), *Brit. med. J.*, **1**, 494.

## ACUTE INTUSSUSCEPTION DUE TO INVERTED MECKEL'S DIVERTICULUM

By JAMES C. GILLIES

HACKNEY HOSPITAL, LONDON

ALTHOUGH inverted Meckel's diverticulum is cited in most surgical text-books as a cause of intussusception, such cases are very infrequent. In the case described below there occurred certain prodromal symptoms presumably due to the inversion of the diverticulum before the major catastrophe of intussusception of the small

bowel itself supervened. These symptoms were not sufficiently characteristic to enable a diagnosis to be made in time.

### CASE REPORT

*HISTORY.*—The child, a boy of  $2\frac{1}{2}$  years, was admitted to Hackney Hospital on Nov 12, 1943.

Up till recently the child was well, with a good colour and a fair appetite. For the last three months he had some abdominal colic and was constipated. The colic seemed worse during the last two weeks, with occasional vomiting, particularly during the last few days. Lately he had been paler than usual.



Fig. 268.—The specimen removed at operation (for description see text).

**ON ADMISSION.**—He was pale and undernourished, with a rather full abdomen in which no masses could be felt. He was lively and playful and did not seem acutely ill. On Nov. 15, a note was made that he was eating very well and there did not seem much the matter beyond anaemia. The Mantoux test was negative. He vomited once on Nov. 19 and once again on the following day.

At 6 a.m. on Nov. 21 he awoke with abdominal pain. His bowels opened twice—small constipated

motions without blood. An enema was given with a moderate result, again without blood. When I saw him at 11.30 a.m. he was pale and wriggling with colicky pain, apparently not enough to make him cry. A large sausage-shaped mass could be felt running from the right iliac fossa beyond the umbilicus.

**AT OPERATION.**—Under general anaesthesia the abdomen was opened by a right paramedian incision. There was some clear free fluid and a large intussusception of the ileo-ileo-colic type. Reduction was obviously impossible. The caecum and ascending colon, with the intussuscepted small intestine, was removed and end-to-end anastomosis made between the small intestine and transverse colon. The specimen is shown in the photograph (Fig. 268).

Dissection of the specimen disclosed an inverted Meckel's diverticulum just over an inch long. It was thickened and hardened by fibrosis and appeared to have been inverted for a considerable time. Although some three inches from the apex of the intussusceptum, it was undoubtedly the primary cause. The base of the intussusception was in the small bowel a few inches from the ileocaecal valve, and the caecum had not been carried up. There was a mass of enlarged glands at the ileocaecal angle, which on section showed chronic inflammation.

**PROGNOSIS.**—The child's condition was poor for the first twenty-four hours, but with intravenous plasma and saline he recovered well. The bowels acted twice on the day following operation, the motions containing blood; thereafter there was no blood. For five days the stools were loose, gradually becoming normal as the colon adjusted itself to its altered condition. Steady progress was made and the wound healed by first intention. The child was discharged on Dec. 10, very well apart from chicken-pox which had just developed.

In the photograph the ascending colon has been retracted and two layers of small intestine incised to display the inverted Meckel's diverticulum. A match-stick has been inserted into the inverted diverticulum on its peritoneal surface.

### SUMMARY

A case of acute intussusception due to an inverted Meckel's diverticulum is reported. Recovery followed resection. Certain prodromal symptoms are attributed to the preliminary inversion of the diverticulum.

My thanks are due to Mr. Andrews, L.C.C. photographer, for the photograph.

## In Memoriam

**SIR CUTHBERT WALLACE, Bart., K.C.M.G., C.B.**

WITH the passing of Sir Cuthbert Wallace we have lost one of the outstanding figures in British surgery of the past generation. He lived through a period in which the practice of surgery was revolutionized by the full application of Lister's principles and the development of medical radiology. He was early to recognize the importance of both these factors and played no little part in extending their intelligent application

to practice. A striking feature of his career is the fact that he continued to take an active and influential part in the advancement of the interests of scientific surgery long after the time in life when most men give up active work; indeed until within a few months of his death.

He was born in 1869, the son of a clergyman. After being at school at Haileybury, he went direct to St. Thomas's Hospital and after a progressive



career as a student, held the posts of Registrar and Resident Assistant Surgeon between 1894 and 1899. Elected to the Staff in 1900, he came with an established reputation as a skilful and economical operator. His clear and orderly mind made him a convinced advocate of a full aseptic

was among the first to advocate active surgical interference at an early stage. Wallace's influence had much to do with the establishment of forward operating centres for abdominal injuries and the founding of the principles of military surgery which have been a guide to the medical services in the present struggle.

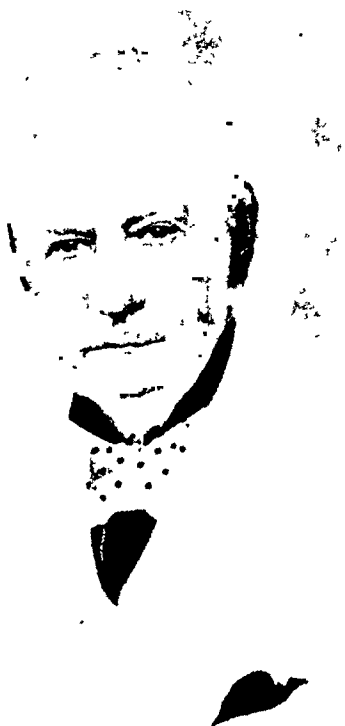
On his return to civil life he took on the posts of Dean to the Medical School and Director of the Surgical Unit at St. Thomas's Hospital. In the difficult period of post-war reconstruction his energy and directness of purpose were of inestimable value to his old school. As a teacher he was sturdily opposed to anything which savoured of cramming for examinations, and ever emphasized the scientific and critical approach to clinical problems. He was essentially a general surgeon, though his chief interests were in urinary and abdominal work. He was slow to lose a dislike and mistrust of the advance of surgical specialization in its narrower sense.

Member of the Court of Examiners from 1919-29 and elected a member of the Council of the Royal College of Surgeons in 1919, he took an active part in promoting the activities of the College for the rest of his life. Elected its President in 1935, he filled the post with distinction, and never failed to receive the support and approbation of his colleagues. On his retirement from St. Thomas's in 1928, he became Medical Director to Mount Vernon Hospital and extended his professional influence and interests to a wide field. He served on the Board of this JOURNAL for five years and was a member of the Radium Commission and the Medical Research Council; he was also appointed to the Army Medical Advisory Council.

Wallace was a singularly lovable man. He was possessed of so patent an honesty of purpose and sincerity of good intention that even those who disagreed with him never became his enemies. Despite his worldly success and the honours which fell to him, he remained simple and approachable by all. Never ambitious to achieve a large practice or of self advertisement, he wrote only when he felt he had something worth saying. A little book produced with Sir John Fraser entitled *Surgery at a Casualty Clearing Station* did not appear till late 1918, but contained an excellent exposition of the essentials of forward surgery as learnt in the last war. Contributions to the *Official Medical History of the War* and several articles in this JOURNAL represent his main output.

Though almost ascetic in his habits, he was a good companion with wide interests and a strong sense of humour; few men in the profession can have had so wide a group of friends and so few enemies. As a chairman he was scrupulously fair and open minded and possessed the happy knack of sizing up the essentials in any discussion.

By his death British surgery has lost a great protagonist and one whose place it will be hard to fill.



SIR CUTHBERT WALLACE, Bart.  
1869-1944

technique in the operating theatre. His energy and enthusiasm were successful in imposing the new methods on his surgical colleagues—not without opposition from the more conservative among them. The new operating theatres at St. Thomas's Hospital, completed in 1904, and the general standard of surgical work at that institution stand as a monument to his success.

In 1899-1900 he gained his first experience of military surgery in South Africa at the Portland Hospital under Sir Anthony Bowlby. The experiences of this campaign were based in the main on rifle bullet wounds which were seldom contaminated, and on a slow transport system. In 1915 Wallace renewed his contact with military surgery as consulting surgeon to the First Army of the B.E.F. He was one of the few consultants to appreciate early the radical change in the character of the wounds met with in France, and

## REVIEWS AND NOTICES OF BOOKS

**Varicose Veins, Haemorrhoids, and Other Conditions.** Their Treatment by Injection. By R. ROWDEN FOOTE, M.R.C.S., L.R.C.P., D.R.C.O.G., Physician-in-Charge, Injection Clinic, Royal Waterloo Hospital, London.  $8\frac{1}{2} \times 5\frac{1}{2}$  in. Pp. 119 + viii, with 54 illustrations. 1944. London: H. K. Lewis & Co. Ltd. 12s. 6d. net.

THIS little book summarizes modern views on injection treatment with sclerosing solutions and is a very practical guide to their use. Like most things medical, injection therapy has followed the swing of the pendulum. A few years before the war varicose veins were everywhere being injected and then recurrences began to appear in large numbers; now the pendulum has swung back, and this book should do much towards the author's expressed hope "to place injection treatment in its proper perspective". Injection treatment for varicose veins, haemorrhoids, hydrocele, hernia, varicocele, bursæ, ganglia, and nævi is discussed, as well as the injection of anal fissures by oily anæsthetic solutions. An appendix contains notes on the organization of an injection clinic and some useful practical hints on the composition of solutions and other relevant matters. The author has no good word for the injection treatment of hernia and merely discusses it to dismiss it; much the same may be said of varicocele. The text is clear, illustrations are good, and this is altogether a well-balanced account which can be recommended as a convenient summary of present views on the subject.

**Gas and Air Analgesia.** By R. J. MINNETT, M.D., D.A., Lecturer in Anæsthetics, University of Liverpool; etc. Second edition.  $6\frac{1}{2} \times 4$  in. Pp. 74 + vi, with 18 illustrations. 1944. London: Baillière, Tindall & Cox. 5s. 6d. net.

THIS small book contains an excellent account of the essential details of gas and air analgesia.

The Minnett apparatus delivers a mixture of nitrous oxide gas mixed with 55 per cent of air, and, skilfully used, will achieve safe and efficient analgesia without injury to the body tissues and a complete freedom from untoward after-effects.

Contra-indications are few, and are enumerated by the author as follows: (1) Heart disease with decompensation; (2) Diseases of the chest, such as phthisis, or chronic inflammatory changes in the lungs; (3) Kidney damage with associated albuminuria and high blood-pressure.

The book deals chiefly with the successful employment of analgesia in midwifery, but Chapter VI gives an account of its application to minor surgery, and we quote the following extract: "In one patient as many as sixty dressings were conducted for the whole of the anterior surface of the arm, 15 in. by 4 in., with sloughing of all superficial tendons, following a septic finger. Other types of dressings and painful manipulations include: perineal after excision of the rectum; deep sinus after nephrolithotomy; those following operation for mastoid; deep anal fistulæ; osteomyelitis of the leg; rectal dilatation; and removal of sixty-two radium needles from the breast. The technique is simple, and consists of instructing the patient to breathe in and out from the apparatus for two to three minutes before the painful manipulation

is commenced, and then to continue the inhalation *all the time* that it is being performed".

We recommend this little book to surgeons, house officers, and general medical practitioners.

**Surgery of Modern Warfare.** Edited by HAMILTON BAILEY, F.R.C.S., Surgeon, Royal Northern Hospital; etc. Sub-editor for Medicine: C. ALLAN BIRCH, M.D., M.R.C.P., D.C.H., D.P.M., M.M.S.A., Senior Physician, North Middlesex County Hospital. Third edition.  $8\frac{1}{2} \times 5\frac{1}{2}$  in. Part IV: Section XI, Wounds of Bones and Joints; Section XII, Wounds of the Hand and Foot; Section XIII, Wounds of Tendons and Peripheral Nerve Injuries; Section XIV, Wounds and Injuries of the Spine; Section XV, Wounds of the Head and Neck. Pp. 507-716, with 244 illustrations. Part V: Section XV, Wounds of the Head and Neck, contd.; Section XVI, Otorrhinolaryngology in Relation to War Injuries; Section XVII, Wounds of the Trunk. Pp. 717-896, with 125 illustrations. Part VI: Section XVIII, Wounds of the Trunk, contd.; Section XIX, Surgical Diseases encountered in Subtropical Countries; Section XX, Administration. Pp. 897-1108, with 146 illustrations. 1944. Edinburgh: E. & S. Livingstone, Ltd. Each Part, 15s. net.

THE third edition of *Surgery of Modern Warfare* is now completed by the issue of Parts IV, V, and VI.

These volumes cover wounds of Bones and Joints; Nerves; Head and Spine; Trunk and Thorax. Part VI also includes a section—not the least interesting—on Administration; An Outline of the Medical Services in the British Army; Transportation of Wounded; The Emergency Medical Service; and Wounds in Naval Action. Then in the final appendix the editor says he tries to supplement omissions and to review literature which has appeared since the work began. All the volumes are profusely and interestingly illustrated. It is an interesting book, and though one may not agree with everything in it, there is no doubt that it is a book any surgeon engaged in war surgery will find useful.

**Illustrations of Regional Anatomy.** By E. B. JAMIESON, M.D., Senior Demonstrator and Lecturer, Anatomy Department, University, Edinburgh. Fifth edition.  $8 \times 6\frac{1}{2}$  in. In seven sections and also in bound volume. Section I: Central Nervous System, 50 plates. Section II: Head and Neck, 64 plates. Section III: Abdomen, 44 plates. Section IV: Pelvis, 35 plates. Section V: Thorax, 32 plates. Section VI: Upper Limb, 42 plates. Section VII: Lower Limb, 52 plates. 1944. Edinburgh: E. & S. Livingstone. Bound volume, 75s. net.

It must be gratifying to both the author and publishers, as is stated in the preface of this, the fifth edition, that the previous one is "running out with a rapidity that is almost embarrassing." It must be an *Embarras de richesses* and presumably this state is a family trait, as the expression, according to the *O.E.D.*, was first used by the missionary who was a namesake of the publishers, in his journal in 1866.

However that may be, students are under a great obligation to the publishers in grudging no expense in adding to the colour of the illustrations and increasing the number in each edition, no less than one hundred and fifty-nine being new in this edition, many of them having seven colours in their make-up—and, as everyone knows, cosmetics are rationed.

No new illustrations are added in the sections on the limbs. "They acquired their full dress in the last edition," and the result is almost as exciting as a 'strip tease'.

It is quite impossible to criticize such a book in detail. With such an author mistakes will be nil. The illustrations are all on only one side of the paper so that the book is really interleaved for the student to make appropriate notes.

Used under the direction of the author it must become an invaluable help to the student by the time he has finished his dissections. On the other hand, it is a book which can equally well be abused by a student, and instead of becoming, as it should, a veritable *vade mecum* for the rest of his professional life, it might quite well, after he has passed his examination, be consigned "into a Limbo large and broad—since called the Paradise of fools, to few 'unknown' with all his anatomical knowledge under the epitaph of *Ave Atque Vale*."

An additional section illustrating the anatomy of surgical approach and access would be a real help to surgeons, and it is hoped that the suggestion will be considered by the author and publishers.

**The Essentials of Modern Surgery.** Edited by R. M. HANDFIELD-JONES, M.C., M.S., F.R.C.S., Surgeon to Out-patients and E.M.S. Commandant, St. Mary's Hospital; etc.; and A. E. PORRITT, M.A., M.Ch., F.R.C.S., Lt.-Col., R.A.M.C., Surgeon to His Majesty's Household; Surgeon to Out-patients and Assistant Director of the Surgical Unit, St. Mary's Hospital; etc. Second edition. 9½ x 6 in. Pp. 1204 + xvi, with 624 illustrations. 1943. Edinburgh: E. & S. Livingstone. 40s. net.

THE first edition of this book from St. Mary's Medical School was published in 1938 and its popularity has evidently justified the author and publishers in issuing a second edition amid the stress and difficulties of war. To the regret of his co-editor, Lt.-Col. A. E. Porritt, owing to his war service, has been unable to co-operate in its production. The new illustrations number 124, and amongst them are six, perhaps rather lurid, which have been taken from oil paintings by Miss Anna Zinkeison.

Many of the illustrations, for which due acknowledgements are made, have been taken from other sources. They are well chosen and amplify the text excellently.

Another point stressed in the preface is that the sulphonamide drug recommended in treatment is always definitely specified by name, rather than by the manufacturer's camouflage. This is an example that might profitably become a routine.

The preface to the first edition stated the author's reason, not excuse, for writing still another text-book—viz., to base the diagnosis on clinical grounds founded on the principles of anatomy, physiology, and pathology rather than on countless laboratory investigations.

The second edition has continued to stress this aspect, which can only be to the advantage of the student and practitioner.

The physiotherapy department at one time was the dumping ground for difficult cases; then, when this

was properly controlled, the radiologists became the salvage sorters; now it is the turn of the laboratory; and unless care is exercised the Rehabilitation Clinics will become the morass of missed diagnoses and bad treatment. The title of the book is *The Essentials of Modern Surgery*. Recently one of our best known critics has criticized the use of the word 'essential'. "This is a word which has been twisted away from its proper meaning. It should imply an article with essence, that is with genuine quality in it, and so substantial, important, full, pregnant. Now, of course, it is simply a synonym for 'necessary'. It would be nice to hear again of an essential picture or poem" (*A Word in Your Ear*, by Ivor Brown, published in 1942 by Jonathan Cape).

The editor claims this is an essential text-book of surgery. It may be a picture and poem as well—who knows?

The question naturally arises, what constitutes a good text-book on such a subject as surgery. Probably the same as that which characterizes a good hostess, viz., poise rather than pose. A text-book, like a hostess, can create an atmosphere which encourages the tired and wearied, and by the absence of boring prosiness raises the interview above the level of duty.

This is a book which by its lay-out and format is easy to read and encourages close acquaintance.

Operative details have as a rule been rightly and intentionally omitted; by more rigid application of this rule valuable space could be saved in subsequent editions for more essential information, particularly is this so in the section devoted to the nervous system. A chapter devoted to the pre-operative preparation of the patient and the post-operative complications would add to the value of the book for the student, and a knowledge of these is now an essential.

It is a mistake in teaching students to tell them that "the term 'tumour' should not be applied to simple hypertrophy and inflammatory re-actions", and after all, 'tumour' simply means 'swelling', and many of the pitfalls in diagnosis are due to the fact that it is not appreciated that all tumours are not neoplastic. It is, moreover, true that the student's attention should be drawn to the grading of malignant neoplasms and their effect on the prognosis. Inflammation is merely the reaction to injury, and though a hæmatoma may not be infected the signs of inflammation are present. It would be more to the point if the difference between the reaction of the tissues to infective and non-infective inflammation were more often stressed. It must be admitted as an essential that the student should realize that healing depends upon rest, non-interference with blood-supply, and prevention of infection. This thesis might be expanded and stressed in every section of the book.

The editors "deplore the tendency evident in the past three years to speak of hæmorrhage and shock as identical states". That may be so, but the shock-hæmorrhage syndrome does keep the difficulties of distinguishing them always in the student's mind, and is worthy of the connecting hyphen.

Moreover, it is doubtful if the 'tourniquet test' is entirely safe to determine the level for amputation in senile gangrene. The danger of tourniquets in general is not mentioned, nor is there any reference to arterial stupor or spasm.

It is also unwise to depend on the anæsthetist to spot that the patient has an Argyll Robertson pupil and so make the correct diagnosis and prevent operative interference. It seems rather late in the case for this observation to be made.

The article on the hand is extremely good and the name of one of the editors is well known in connexion with this type of injury, which now probably causes more disability in industry and loss of working days than any other, and it is well that the term 'whitlow' is decently interred.

The chapter on Thoracic Surgery is very good and concise, what one has been led to associate with the author, whereas that on appendicitis is unnecessarily obtruse, so that the student will have difficulty in correlating the pathology with the physical signs. This chapter has not been revised for this edition, but no doubt will be when the author returns from his enforced absence abroad, for which all his friends will be very thankful.

The use of radiology in the diagnosis of acute obstruction is now admitted and might well be included as an essential in modern surgery; the next edition may include this extra aid to diagnosis, and also the fallacy of relying on X rays for the diagnosis of carcinoma of the rectum to the exclusion of sigmoidoscopy should be stressed.

Teaching to be effective must be dogmatic, so statements such as "although it is desirable to save the gall-bladder whenever possible, it must be admitted, it is rarely justifiable to leave it" reflect the ambiguous phrasing of many war-time observations. The more vernacular way of putting it is "passing the buck".

The clinical signs and diagnosis of genito-urinary diseases is good, but the fundamental pathology might well be revised.

It is easy to criticize, but to edit a text-book of this nature during the present time can be no light task. It fulfils its object in that the clinical signs of disease are stressed throughout and the basic principles upon which such diagnosis is founded.

If this book is carefully read and pondered, the student will be encouraged to ask himself and answer the questions How? Why? When? and realize the truth of the statement:—

"I had six trusty serving men  
Who taught me all I knew,  
Their names are How and Why and When  
And Where and What and Who."

**Demonstrations of Physical Signs in Clinical Surgery.** By HAMILTON BAILEY, F.R.C.S. (Eng.), Surgeon, Royal Northern Hospital, etc. Ninth edition.  $8\frac{1}{2} \times 5\frac{1}{2}$  in. Pp. 351 + viii, with 492 illustrations, a number of which are in colour. 1944. Bristol: John Wright & Sons Ltd. 25s. net.

THE dispersal of patients demanded by war has led to a dearth of collected 'good teaching cases' in the wards and out-patient departments of the teaching hospitals; it is therefore all the more important for the student to have some complete guide to the basic physical signs of clinical surgery and their interpretation. He will find it here, attractively presented, profusely illustrated, easily readable, and with biographical footnotes about the originators of all the signs named. As a companion to the text-books which the surgical dresser should read, it has no equal.

We have found one minor misprint—on page 39, where the reference should be to Fig. 58, not Fig. 51—but the whole volume bears such evidence of care, both in its preparation and publication, as to call forth our praise and admiration; nine English editions in seventeen years are a sufficient index of its popularity.

**A Field Surgery Pocket Book.** By VARIOUS AUTHORS.  $7\frac{1}{2} \times 4\frac{3}{4}$  in. Pp. 172, with 13 illustrations. 1944. London: The War Office. Not on sale.

THIS little manual, which is the result of over four years' experience of war surgery, should prove of real worth to all medical officers in the fighting forces. Up till now there has been a great tendency to base all experience on the 1914-18 war, to the exclusion of modern methods.

This book is the considered experience of the Army Consultants gleaned from every theatre of war, and is an excellent production of which General Sir Alexander Hood may well be proud.

**The Diseases of the Endocrine Glands.** By HERMANN ZONDEK, M.D. (Berlin), Director of the Medical Division, Bikur Cholim Hospital, Jerusalem. Fourth (Second English) edition. Translated by CARL PRASNITZ GILES, M.D. (Breslau), M.R.C.S. (Eng.), L.R.C.P. (Lond.).  $9 \times 5\frac{1}{2}$  in. Pp. 496 + viii, with 180 illustrations. 1944. London: Edward Arnold & Co. 40s. net.

THE translation of this book—the second English edition—follows on general lines the last German edition, which appeared in 1926. After leaving Germany, Professor Zondek went to the Jewish Hospital, Manchester, and later to Jerusalem, where he is now Director of the Medical Section of its hospital.

Although the general scheme remains the same, the author has taken advantage of including most of the more recent advances in the knowledge of the physiology and pathology of the internal secretions. The book is primarily intended for the clinician, but it is also a closely documented compendium giving the experimental data and opinions of this widely expanding subject. Indeed, an understanding of the interplay of hormones between the various tissues and organs of the body is becoming more and more necessary in the sphere of clinical assessment. It enters into such factors as metabolism, circulation, the distribution of blood, and the correlation of the various vegetative functions. Indeed, the author supports the modern contention that the endocrine glands play an intermediary part between some of the functions of the body and the mind. Changes in the endocrine glands may affect the mind, and mental disease in its turn may affect the hormonal glands. He also makes it clear that functional and anatomical changes in the endocrine glands should not necessarily be regarded as the cause of any particular disease, but in some cases as a reaction to disease elsewhere. The manifestations of disease, therefore, are not so much the effect of any particular hormone, but of the varying responses of the tissues towards it. This linking up of biology and pathological physiology with endocrinology is one of the more interesting developments in this field of research. An extensive literature from Europe, this country, the United States, and Canada is quoted, the experimental evidence is sifted and conclusions are drawn. In this respect the book serves as a useful reference to those who wish to consult the literature or study the experimental data on any of its subjects. It would be invidious to make any detailed criticism of a book covering such a wide field. The pituitary and thyroid are extensively dealt with, but there is a good deal of modern work upon the adrenal and gonad, especially that on steroid metabolism, which

could be incorporated with profit. The author is to be congratulated not only upon his international search of his facts, but on their presentation in a practical form. His broad views, while stressing the potentialities of his subject, allay much of the suspicion that has gathered round the subject of organotherapy, and bring its claims into a proper and reasoned perspective.

**An Atlas of Anatomy.** By J. C. BOILEAU GRANT, M.C., M.B., Ch.B., F.R.C.S.(Edin.), Professor of Anatomy in the University of Toronto. In two volumes. 11 x 8½ in. Vol. I, Upper Limb, Abdomen, Perineum, Pelvis, and Lower Limb. Vol. II, Vertebrae and Vertebral Column, Thorax, Head, and Neck. Pp. 390 + xii, with 460 illustrations. 1943. Baltimore: The Williams & Wilkins Co. (London: Baillière, Tindall & Cox). The set, 55s. net.

ALTHOUGH many books have been produced which were designed to give a pictorial expression to anatomy, there is always room for a newcomer—provided that it is practical and instructive. The modern student of medicine has such a vast curriculum at present that it is imperative that he should have a sound knowledge of regional anatomy. These volumes can provide that knowledge.

Volume one is devoted to the upper limbs, abdomen, perineum, pelvis, and lower limbs. It contains 227 illustrations.

The regional presentation not only reflects the method of dissection that is taught in American schools, but also makes the *Atlas* permanently useful in clinical work. Many a time a surgeon requires to refresh his memory concerning the anatomy of this or that region.

The drawings are first class and are by Dorothy I. Chubb, a pupil of the late Max Broedel. It is refreshing to see new illustrations which do depict accurately the anatomical relationships.

Professor Grant has taken meticulous care in the preparation of the specimens depicted and they are a real credit to the Toronto school.

War surgery has made a universal demand for such an atlas of anatomy and teachers and students, physicians and surgeons, will one and all find this volume of real value and usefulness.

### The Hospital Care of the Surgical Patient.

**A Surgeon's Handbook.** By GEORGE CRILE, jun., M.D., Surgeon, Cleveland Clinic, and FRANKLIN L. SHIVELY, jun., M.D., Assistant Surgeon, Cleveland Clinic. With a Foreword by EVARTS A. GRAHAM. 8½ x 5½ in. Pp. 184 + xv, with 21 illustrations. 1943. Springfield, Ill.: Charles C. Thomas (London: Baillière, Tindall & Cox). 14s. net.

THIS small volume (184 pages) is intended to standardize the technique of the common surgical procedures for the guidance of interne and resident staffs. It presents the physiological background and rationale, as well as a detailed description of those techniques that are of importance in pre-operative and post-operative care. It is neatly illustrated, very readable, and the principles which it advocates are sound. Small clinics and hospitals in which the senior staff have neither the time nor the inclination to maintain a "precedent book" for the use of their resident staff will find this contribution of considerable value. The discussion of the relationship of the house officer

to his patient and to other members of the hospital staff is especially well done.

On the other hand, a book such as this requires such constant revision to keep abreast of the times that most teaching institutions will prefer to maintain a "precedent book" of their own. For example, gum acacia is mentioned as a plasma substitute (p. 13), and the technique of blood transfusion recommended by the authors would be regarded by many as antiquated. In general, the discussion of shock therapy is not in accord with the more advanced views on this subject. Thus, the statement, "shock is invariably accompanied by a low blood-pressure and usually disappears as soon as the pressure is restored to normal" (p. 59), is open to considerable criticism. One also would like to have seen a discussion of the principles involved in the use of stored blood.

Many similar minor criticisms could be made. The technique of catheterization as recommended is too elaborate for the use of most busy urological services. In the treatment of pulmonary embolism heparin is advised with an optimism which is no longer justified, and the use of vein ligation is not mentioned.

In general, the book is poorly organized. Under Section II, *The Management of Surgical Complications*, one finds as sub-headings, *Preoperative Care of the Patient for Operation*, *Post-operative Care*, and *Hyperthyroidism*, none of which can be considered as surgical complications.

The usefulness of this book to small hospitals would be greatly enhanced by a section on the primary care of the common surgical emergencies.

### The 1943 Year Book of Industrial and Orthopedic Surgery.

Edited by CHARLES F. PAINTER, M.D., Orthopedic Surgeon to the Massachusetts Women's Hospital and Beth Israel Hospital, Boston. 7 x 4½ in. Pp. 440, with 306 illustrations. 1943. Chicago: The Year Book Publishers Inc. \$3.00.

THIS year book is a condensed review of current thought on orthopedic and allied industrial problems. It is in fact a kaleidoscopic commentary, picking out the highlights of modern diagnosis and treatment.

The chapters arrange themselves under five main headings: *Fractures*, *Infections*, *Tumours*, *Congenital and Acquired Defects*, and *Industrial Considerations*.

In many of the papers a healthy undertone is apparent, engendered by the need for reducing absenteeism from work during this critical war period. Evidence of this lies in modifications of treatment and splintage, methods for preventing the secondary disabilities of trauma, and a presentation of the industrial aspects of the problem.

Much of the work on bone infection will have to be reviewed in the light of more recent experience with penicillin.

The section on tumours is short but contains interesting descriptions of some rare conditions.

The remainder of the surgical section consists of a wide variety of annotations ranging from low back pain to immersion foot.

The industrial section is primarily of interest to the industrial medical officer. It should, however, serve as a reminder that the surgeon undertaking treatment of industrial accidents should be familiar with the conditions under which the patient earns his living.

The subject matter in this book is well chosen. It is astutely edited, generously illustrated, and fully referenced. It is a worthy comrade for its predecessors and deserves a place on the bookshelf of the progressive surgeon.

**The Radiology of Bones and Joints.** By JAMES F. BRAILSFORD, M.D., Ph.D., F.R.C.P., F.I.C.S., Hunterian Professor, Royal College of Surgeons, England, 1934-5, 1943-4; Radiological Demonstrator in Living Anatomy, The University of Birmingham; etc. Third edition.  $9\frac{1}{2} \times 7\frac{1}{4}$  in. Pp. 440, with 404 illustrations, mostly plates. 1944. London: J. & A. Churchill. 45s. net.

THIS is the third edition of what has become almost an encyclopædia on bone radiology. It has been much enlarged and rewritten and many new radiographs and tracings of radiographs have been added.

Many rare bone lesions are described, as well as the more common conditions, and very many references are given throughout the book. The general effect is to make it an excellent reference book on peculiar X-ray appearances of bones and joints. The author has an amazing faculty for broadening the whole aspect of bone radiology, and his discussions extend into the realms of biology as well as pathology. It contains many original observations and puts forward theories in regard to many obscure conditions.

There is a tendency to be dogmatic for the sake of clarity and to over-simplify some of the difficulties of X-ray diagnosis. This contrasts with his open mind in regard to the many references he quotes. Often these are obviously at variance with the author's expressed views, but he leaves it to the reader to decide on the merits of conflicting theories. From the point of view of the surgeon, the clinical matter is rather in the background and there is little guide to treatment, but this is in keeping with the object of the book, which is essentially X-ray diagnosis and the contribution of radiology to some problems of hereditary pathology.

War-time paper has necessitated the radiographs being reproduced on special paper and so they are often rather remote from the text, while the system of numbering under the same file the radiographs on their special pages and the line tracings on other pages leads to some difficulty in finding the required illustration. It would have been easier to add the page number as well as the illustration number, where such confusion exists.

**Modern Operative Surgery.** Edited by G. GREY TURNER, LL.D., D.Ch., M.S., F.R.C.S., F.R.A.C.S., F.A.C.S., Professor of Surgery in the University of London and Director of Surgery at the British Post-graduate Medical School, etc. Third edition. In two volumes.  $9\frac{1}{4} \times 6\frac{1}{2}$  in. Vol. II., Pp. 1043-2236, with 559 illustrations. 1944. London: Cassell & Co. Ltd. 55s. net.

COMPARISON with the second edition shows how many improvements have been introduced, both in the subject matter and in the illustrations, in every chapter of this latest version of *Modern Operative Surgery*. So much care has been taken over the work as a whole that it seems hardly fair to single out sections for special comment; yet it is proper to note the contributions of authors who are newcomers to this volume. In the chapter on the oesophagus the editor has had the collaboration of V. E. Negus, who is also responsible for a separate section

on the investigation of the upper air and food passages. This front-line zone of surgical advance is thus most adequately covered; and in the same region A. J. Gardham has done a fine piece of work in bringing up to date the surgery of the lips, jaws, mouth, tongue, and salivary glands. W. E. M. Wardill has done similarly for the surgery of hare-lip and cleft palate, and is to be commended for giving the reader a clear idea of problems about which the views of the experts are subject to continual change. Gynæcological operations have been capably handled by L. Carnac Rivett, and the surgery of the bladder and prostate, including the various endoscopic techniques, has been very satisfactorily described by Ogier Ward. Though Jefferson cannot be counted a newcomer to the work, his chapter on the surgery of the skull and brain is entirely new, and stands out as a model of what the general surgeon should receive from the specialist. The keynote of the whole work is practicability—it tells the young surgeon the most useful thing to do under given circumstances, with ample practical detail to enable him to avoid pitfalls, and to carry the job through successfully in spite of lack of experience. Criticisms seem trivial, yet perhaps we may be allowed to say that the operation for umbilical hernia designated 'ideal' may not be accepted as such by the majority of surgeons, and that in future editions it may be possible to avoid unnecessary duplication in the description of operations upon brain abscess, cervical glands, and the presacral nerve. These are minor matters and cannot chill the warmth of our welcome to this admirable volume.

**Endocrine Man.** A study in the Surgery of Sex. By L. R. BROSTER, O.B.E., D.M., M.Ch. (Oxon.), F.R.C.S., Hon. F.A.S.A., Surgeon, Charing Cross Hospital. With a Foreword by Sir PETER CHALMERS MITCHELL, C.B.E., D.Sc., F.R.S.  $8\frac{1}{2} \times 5\frac{1}{2}$  in. Pp. 144 + xii. 1944. London: William Heinemann (Medical Books) Ltd. 12s. 6d. net.

It must sometimes happen that a reviewer will find that the subject matter of the book under review lies outside the range of personal knowledge, and seeing that a critical survey is impossible has to content himself with a short statement of what the book is about. This describes the position of the present writer, and it is suggested, with diffidence, that it may be the same with other readers of the *BRITISH JOURNAL OF SURGERY*, because the subject matter is little known and probes the intimate penetralia of our very nature and deals with that "disputable boundary" which our own medical Poet Laureate calls "the misty march lands . . . between matter and mind". In the preface Mr. Broster says that the basis of the book rests on the work on the adreno-genital syndrome done at Charing Cross Hospital during the last fifteen years, and the story is told of the early operations on the adrenal glands undertaken for the relief of virilism. But the book deals with much more than the vagaries of growth and behaviour due to endocrine eccentricity, for there are chapters on Instinct, on Heredity, on the Diencephalon, on Symbiosis and Parasitism, and finally on the Nature of Man.

There is much in the book that lies beyond the range of general surgery and therefore, it might be argued, there is all the more reason why the surgeon should read it, as well as the biologists, as the writer of the Foreword, Peter Chalmers Mitchell, recommends.

**Regional Analgesia.** By H. W. L. MOLESWORTH, F.R.C.S. Eng., Senior Surgeon, Royal Victoria Hospital, Folkestone; etc.  $8\frac{1}{2} \times 5\frac{1}{2}$  in. Pp. 90 + viii, with 42 illustrations. 1942. London: H. K. Lewis & Co., Ltd. £s. 6d. net.

In his preface the author writes: "The small book which follows does not aim at being a text-book on the subject, but is rather presented as the author's personal experience with a method which has been interesting and useful to him in the practice of a general surgeon". It is from this viewpoint that we recommend this book to surgeons and anaesthetists.

We note certain omissions, but as this is not a text-book, it cannot be expected to contain details of all modern techniques and analgesic drugs. The author does, however, present us with an excellent description of the methods he has successfully used in his own practice.

Mr. Molesworth is obviously an enthusiastic user of regional analgesia, and like every good workman is careful of his tools, as is evidenced in the following

extract: "We prefer needles of carbon steel, which take a finer edge and slide through tissues with less friction. After use servicing should not await the end of the day's operating, they should be washed through with distilled water, alcohol, and ether in that order. They should be dried on a warm metal plate, points inspected, and if necessary rubbed on a fine Arkansas slip, taking great care to maintain the original bevel and lancet point. A dry stilette is greased with sterile vaseline and inserted into each bore, and the needle is put away in its protective sheath ready for its next sterilization by boiling. We have needles which have been in use for ten years and which have been serviced in this way. In most hospitals they last a few weeks only."

Many surgeons will agree with the author in looking forward to the time when regional analgesia will be carried out by an anaesthetist as a routine, so that if the results are not all they should be, "this will restore to the surgeon that desirable state of affairs in which the blame may sit firmly on the shoulders of another."

## BOOK NOTICES

*[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.]*

**After-treatment.** A guide to General-Practitioners, House-Officers, Ward-Sisters, and Dressers in the care of patients after operation. By H. J. B. ATKINS, D.M., M.Ch. (Oxon.), F.R.C.S. (Eng.), Assistant Surgeon to Guy's Hospital. Second edition.  $8\frac{3}{4} \times 5\frac{1}{2}$  in. Pp. 311 + xvi, with 60 illustrations. 1944. Oxford: Blackwell Scientific Publications Ltd. 18s. net.

**Recent Advances in Anaesthesia and Analgesia** (including Oxygen Therapy). By C. LANGTON HEWER, M.B., B.S. (Lond.), D.A. (Eng.), Senior Anaesthetist, St. Bartholomew's Hospital and St. Andrews' Hospital, Dollis Hill; etc. Fifth edition.  $8 \times 5\frac{1}{2}$  in. Pp. 343 + viii, with 141 illustrations. 1944. London: J. & A. Churchill Ltd. 18s. net.

**The Rehabilitation of the Injured.** Occupational Therapy. By JOHN H. C. COLSON, Technical Director of Rehabilitation, Accident Service, Royal Sheffield Infirmary and Hospital. With a Foreword by E. A. NICOLL, M.D., B.Ch., F.R.C.S. (Edin.).  $8\frac{1}{2} \times 5\frac{1}{2}$  in. Pp. 226 + xvi, with 196 illustrations. 1944. London: Cassell & Co. Ltd. 15s. net.

**Operative Procedure.** A series of plates, published in surgical journals of the United States of America, prepared in collaboration with the staff of Surgery, Gynecology and Obstetrics.  $9 \times 6$  in. 100 plates. 1944. Slough, Bucks.: Johnson & Johnson (Great Britain) Ltd. 5s. net.

**The Surgery of Abdominal Trauma.** By GEOFFREY E. PARKER, M.B., B.Ch.; F.R.C.S. (Eng.), Surgeon to the French Hospital, London; Surgeon to the Woolwich War Memorial Hospital; Surgeon to the Erith and District Hospital, Kent; Major, R.A.M.C. With a Foreword by Col. J. M. WEDDELL, C.B.E., F.R.C.S.  $8 \times 5\frac{1}{2}$  in. Pp. 120 + viii, with 10 illustrations. 1944. London: J. & A. Churchill Ltd. 10s. 6d. net.

**Minor Surgery.** By R. J. MCNEILL LOVE, M.S. (Lond.), F.R.C.S. (Eng.), F.I.C.S., Surgeon, Royal Northern and Metropolitan Hospitals; etc. Second edition.  $7 \times 4\frac{1}{2}$  in. Pp. 392 + viii, with 201 illustrations. 1944. London: H. K. Lewis & Co. Ltd. 15s. net.

**Textbook of Surgical Treatment**, including Operative Surgery. Edited by C. F. W. ILLINGWORTH, M.D., Ch.M., F.R.C.S.E., Regius Professor of Surgery, University of Glasgow. Second edition.  $9\frac{1}{2} \times 6\frac{1}{2}$  in. Pp. 564 + xii, with 230 illustrations. 1944. Edinburgh: E. & S. Livingstone Ltd. 30s. net.

**Notable Names in Medicine and Surgery.** By HAMILTON BAILEY, F.R.C.S. (Eng.), Surgeon, Royal Northern Hospital, London; and W. J. BISHOP, F.L.A., Sub-Librarian, Royal Society of Medicine.  $7\frac{1}{2} \times 4\frac{3}{4}$  in. Pp. 202 + viii, with 142 portraits and other illustrations. 1944. London: H. K. Lewis & Co., Ltd. 15s. net.

**Aids to Theatre Technique.** (Nurses' Aid Series). By MARJORIE HOUGHTON, S.R.N., S.C.M., D.N., Sister Tutor, University College Hospital; and MARGARET HARDING, S.R.C.N., S.R.N., S.C.M., Senior Theatre Sister, University College Hospital. With a Foreword by WALPOLE LEWIN, M.S. (Lond.), F.R.C.S., Capt. R.A.M.C., late Harker Smith Registrar and Assistant to Surgical Unit, University College Hospital.  $6\frac{3}{4} \times 4\frac{1}{2}$  in. Pp. 262 + xiii, with over 100 illustrations. 1944. London: Baillière, Tindall & Cox. 4s.

**X-Ray Examination of the Stomach.** A Description of the Roentgenologic Anatomy, Physiology, and Pathology of the Esophagus, Stomach, and Duodenum. By FREDERIC E. TEMPLETON, M.D., Head of the Department of Roentgenology, The Cleveland Clinic.  $9 \times 6$  in. Pp. 516 + iv, with 297 illustrations. 1944. Chicago: University of Chicago Press. (London: Cambridge University Press.) 60s. net.



# THE BRITISH JOURNAL OF SURGERY

VOL. XXXII

JANUARY, 1945

No. 127

## WOUNDS OF THE COLON

By BRIGADIER C. NAUNTON MORGAN

CONSULTANT SURGEON, PERSIA/IRAQ FORCE; ASSISTANT DIRECTOR, SURGICAL UNIT, AND  
ASSISTANT SURGEON, ST. BARTHOLOMEW'S HOSPITAL

THIS review of wounds of the colon, though not complete owing to the fact that most of the data were obtained from reports at Base Hospitals, will, it is hoped, be useful and of interest, since not only has the average war surgeon a restricted experience of colon wounds, but he is often unable to follow up all his cases in detail.

The improved results of war surgery of the abdomen are, in the main, the outcome of all those factors which, in the fifteen years or so *before the outbreak of war, were producing better results in civil surgery.* It is in the field of pre-operative and post-operative treatment that the most important advances in abdominal surgery have been made in recent times. Surgeons in the Middle East were privileged to be amongst the first to apply these advances in surgery to the treatment of wounds in battle.

The time-lag factor in wounds of the abdomen, though important, must not overshadow the sober need for skilled post-operative nursing. A lone Field Surgical Unit (F.S.U.) working with a Field Ambulance, though it can deal with a proportion of wounds of the first urgency—hæmorrhage, sucking chest wounds, and abdominal wounds—is of little avail if the latter succumb from lack of skilled after-care. It is a fact that abdominal cases travel badly, but it is not so much the ill effects of travelling that matter, as the difficulty of proper pre- and post-operative care during transit. A forward surgeon who operates on abdominal wounds must be so placed that he can retain his patients for at least a week or preferably 10 to 14 days, and have at hand all the necessities for thorough treatment and nursing. The surgeon must not be regarded as a travelling saviour of lives, but part of a team which can give the best treatment to the largest number of wounded, an essential part of this team being a Field Transfusion Unit (F.T.U.). He must be available to give cases of internal hæmorrhage a chance of survival, though severe internal hæmorrhage is usually beyond surgical aid. Treatment of wounds of the abdomen can wait, when necessary, for a few hours, since gastro-intestinal contents do not, as a rule, pour

out into the general peritoneal cavity. Although it is undesirable as a general rule, in exceptional circumstances, such as commando raids or during the initial period of a sea or airborne landing, or when the military situation demands it, F.S.U.'s and F.T.U. may work with a Field Ambulance, since rapid evacuation of wounded may be impossible.

It has been found that two F.S.U.'s and one F.T.U., attached to a Casualty Clearing Station (C.C.S.), a light section of the C.C.S., or a Field Dressing Station, form a good working arrangement, since it minimizes pre-operative delay. The F.T.U. not only prepares and helps to select cases for operation, but also assists in the post-operative treatment, especially the parenteral administration of fluids, etc. Grouping of C.C.S.'s with their attached F.S.U.'s and F.T.U.'s to form an Operating Centre is sometimes desirable. Reserve F.S.U.'s may be held in readiness and moved rapidly, with or without their basic operating equipment, to relieve or to assist overworked teams.

*In this war the surgeon is probably seeing and operating on cases which, in the last war, died before reaching skilled aid; almost hopeless cases have been operated upon.* An increased operability rate, in spite of an increased mortality, will, up to a point, save more lives, but the optimum limit and the limit of optimism may easily be passed unless the young and fearless surgeon is placed not only in the right tactical, but in the correct surgical, position. Front-page drama in abdominal surgery does not pay—the handicaps of working without a Transfusion Unit, a skilled anaesthetist, a good light, an adjustable operating table, and adequate arrangements for nursing and after-care, are too great for even the most enthusiastic surgeon.

It is with sincere admiration and homage that I add my tribute to the skill, courage, perseverance, and judgement of the forward surgeons in whose hands the badly-wounded soldier is placed.

It is unwise to draw too many conclusions from study of wounded at the Base, since the



forward surgeon alone knows of his failures and disappointments; the survivors tell only of the triumphs. It will be realized that a primary mortality figure cannot be given, since most of the case reports analysed in this study are of those who survived their wounds. Major-General Ogilvie, in his masterly and frank review

colon, and sigmoid colon) were injured in about equal frequency. The transverse colon, however, was twice as often the site of damage when compared with each anatomical portion of the large intestine (Fig. 269, A). The same relative proportions were found when survivors alone were considered (Fig. 269, B).

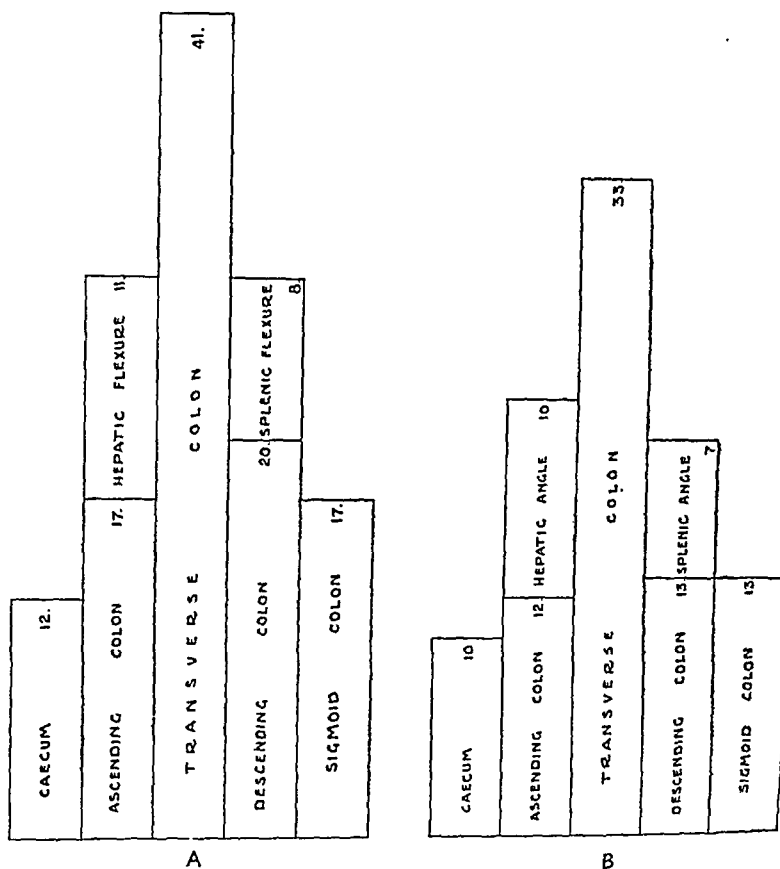


FIG. 269.—A, Relative sites of colon injuries (126 colon wounds in 120 patients). B, Relative sites of colon injuries in survivors (98 lesions in 94 patients).

of "Abdominal Wounds in the Western Desert", showed the following mortality rates:—

*All cases* (complicated and uncomplicated): Colon, 51.5 per cent; colon and small intestine, 62.5 per cent (cf. 74 per cent in last war).

*Uncomplicated cases*: Colon, 43.9 per cent; colon and small intestine, 58.6 per cent.

*Uncomplicated cases operated upon within 12 hours*: Colon, 40 per cent; colon and small intestine, 55.5 per cent.

From the following analysis of 122 cases of wounds of the colon, 109 penetrating and 13 non-penetrating, there emerge, however, certain interesting facts.

**Frequency of Site of Injury.**—In 120 soldiers with 126 injuries of the colon, it was found that the right colon (caecum, ascending colon, and hepatic flexure), the transverse colon, and the left colon (splenic flexure, descending

colon, and sigmoid colon) were injured in about equal frequency. The transverse colon, however, was twice as often the site of damage when compared with each anatomical portion of the large intestine (Fig. 269, A). The same relative proportions were found when survivors alone were considered (Fig. 269, B).

**Site of Entry Wound in Relation to Portion of Colon Injured.**—In 106 wounds of the colon in which the position of the wound of entry was known, there was approximately an equal number of right, left, and transverse colon lesions, but a difference in the frequency of the site of the entry wounds was apparent (Fig. 270, A).

34 wounds right colon—abdominal entry wound in 15 instances (44 per cent).

35 wounds transverse colon—abdominal entry wound in 25 instances (70 per cent).

37 wounds left colon—abdominal entry wound in 13 instances (35 per cent).

A more detailed analysis of the position of the entry wound in relation to the site of colon

damaged is shown (Fig. 270, B). The relation of the wound of entry to the wound in the colon in survivors is shown (Fig. 271, A, B).

It will be seen that, whilst the cæcum and transverse colon were most frequently injured from the front, the ascending colon with the

In late cases a surgeon may be rewarded more often than is generally realized.

From a study of Fig. 272, it will be seen that among cases operated upon within 6 hours there is a preponderance of those with injury to the transverse colon, whereas in the second 6-hour period there is a big fall in the number of survivors following injury of this segment.

Associated intra-abdominal injuries complicating wounds of the colon are most frequent in the case of the transverse colon (63 per cent) (see Tables C and D).

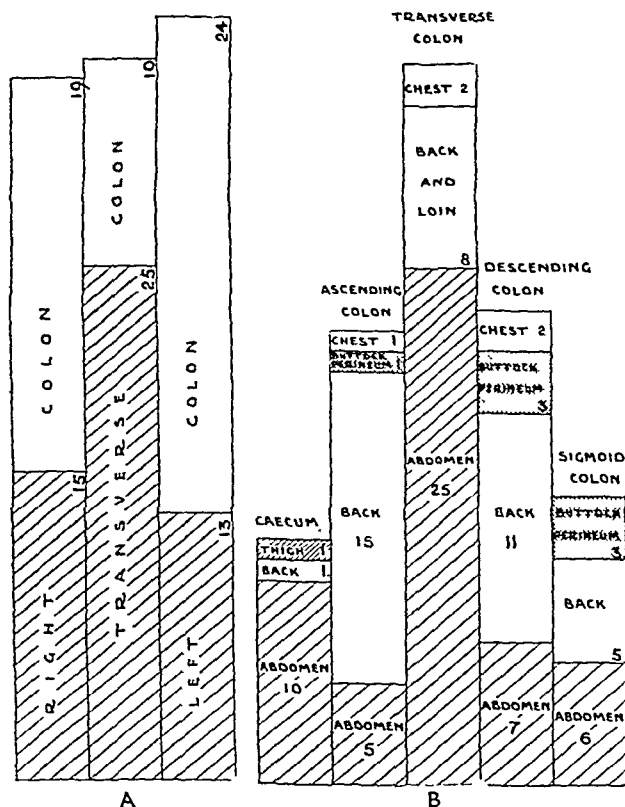


FIG. 270.—A, Analysis of 106 wounds of the colon showing relative frequency of entry wounds in anterior abdominal wall compared with entry wounds elsewhere. Anterior abdominal entry wounds shaded. B, Detailed analysis of wounds shown in A.

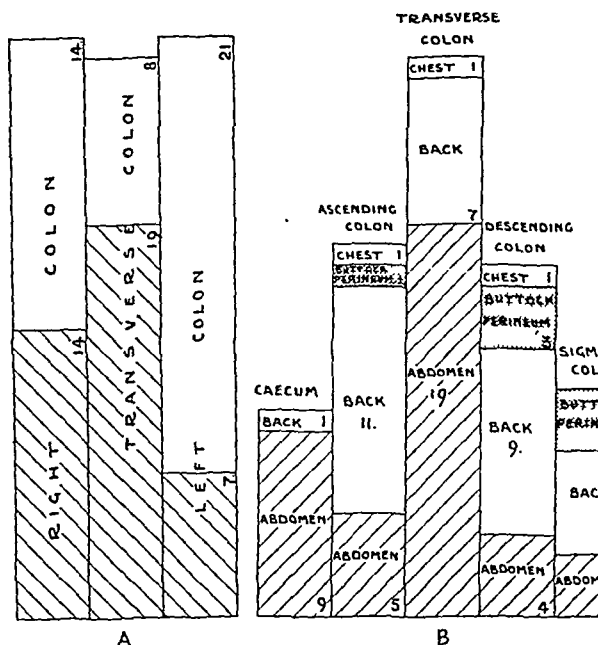


FIG. 271.—A, Analysis of 83 wounds of the colon in survivors. Those with anterior abdominal entry wounds are shaded. B, Detailed analysis of wounds shown in A.

hepatic angle, and the descending colon including the splenic angle, were usually injured from the back. The sigmoid colon sustained damage from missiles entering either anteriorly, posteriorly, or from below. It is noteworthy that the fixed ascending and descending colon were not as commonly injured from the front as the other portions of the colon.

Wounds of the lower quadrants of the abdomen appear to have involved the colon twice as frequently as those in the upper half (Table A).

**Relation of Time-lag, Recovery, and Site of Colonic Injury.**—The time-lag was known in 63 cases surviving for 28 days or longer, but 7 of these had non-penetrating wounds. Accordingly, only 56 cases are available for this analysis (Fig. 272).

It will be noted that 17 cases recovered after a time-lag of over 12 hours (over one-third); 8 cases recovered after over 18 hours (one-seventh); 5 cases recovered after a pre-operative delay of 24 hours (one-eleventh).

Table A.—SITE OF ABDOMINAL ENTRY WOUNDS IN QUADRANTS  
(38 cases; 28 survivors)

RIGHT UPPER QUADRANT	LEFT UPPER QUADRANT
7 { All wounds of transverse colon	6 { 3 Transverse colon 3 Splenic angle
[ Survivors— 7 { All wounds of transverse colon ]	[ Survivors— 3 { 1 Transverse colon 2 Splenic angle ]
RIGHT LOWER QUADRANT	LEFT LOWER QUADRANT
11 { 7 Cæcum 1 Ascending colon 3 Transverse colon	14 { 6 Transverse colon 4 Descending colon 3 Sigmoid colon 1 Cæcum
[ Survivors— 9 { 6 Cæcum 3 Transverse colon ]	[ Survivors— 9 { 5 Transverse colon 2 Descending colon 1 Sigmoid colon 1 Cæcum ]

The number of survivors is approximately equal for wounds of each segment of the colon (Fig. 269, B); of 98 wounds of the colon in 94 survivors, there are 32 right colon lesions, 33 transverse colon lesions, and 33 left colon lesions.

Bearing these facts in mind, the sudden fall in the number of cases of injury of the transverse colon surviving after the first 6-hour period is probably due to the increased risk of severe hæmorrhage from the wide expanse of vascular mesentery, mesocolon, omentum, or from injury

with one of the distal colon. However, in the small group of 17 cases surviving after a time-lag of 12 hours, 11 were in the right and transverse colon, and of the remaining 6, 3 were in the mobile sigmoid (Fig. 272).

**Frequency of Associated Wounds of Other Abdominal Organs.**—It is well known that the small intestine is the abdominal organ most frequently involved in penetrating injuries of the abdomen, but wounds of the colon occur not much less frequently. In 205 penetrating wounds involving the abdominal viscera, extracted from Ogilvie's paper on "War Injuries of the Abdomen", it is found that 73 had sustained wounds of the small intestine, whilst 53 suffered from wounds of the large intestine—a ratio of 7 to 5.

In this series of 128 wounds of the colon (122 cases), concomitant injury to other abdominal

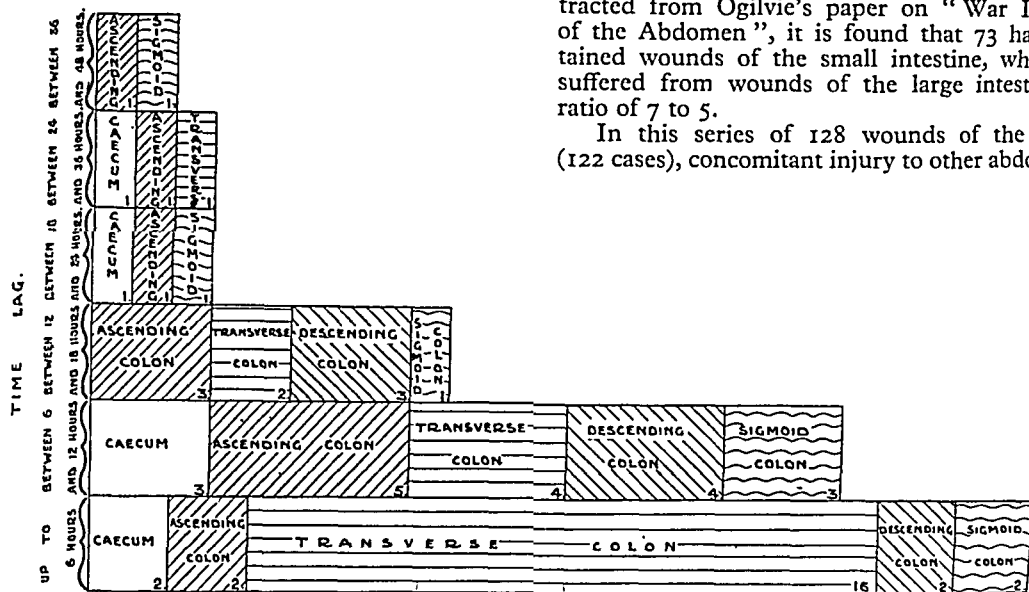


FIG. 272.—Sixty penetrating wounds of the colon in 56 survivors (over 28 days) showing time lag and site of lesion. There were 4 cases with wounds of 2 portions of the colon. There were 4 transverse colons with associated wounds in the descending colon 2, ascending colon 1, and sigmoid colon 1; all were cases within 12-hours time lag.

to other abdominal organs. Unless the cases reach the surgeon quickly enough, hæmorrhage will rapidly prove fatal. Once hæmorrhage is controlled, there are, in general, few technical difficulties attending the treatment of a wound in this portion of the colon, owing to its mobility.

One might have expected that wounds of the right and transverse portions of the colon would be less lethal than the remainder, since not only are the organisms less virulent, but the cæcum and transverse colon can be exteriorized with the minimum of interference, whereas on the left side, apart from the sigmoid loop, mobilization is difficult. The better blood-supply of the proximal colon increases the risk of severe hæmorrhage, and this, together with the greater frequency of other abdominal injury, balances the increased chances of infection experienced in the surgery of the left colon.

It is difficult at this stage to obtain a large enough series of wounds of the colon sufficiently recorded to form a definite opinion as to whether a soldier surviving the first 12 hours is more likely to live with a wound of the proximal than

organs occurred in 42 per cent. The organ most frequently injured in addition to the large gut was the small intestine; this occurred in 31 per cent; the small intestine and colon alone were involved in 25 per cent. In 9 per cent of

Table B.—INCIDENCE OF ASSOCIATED INJURY OF OTHER ABDOMINAL ORGANS WITH LESION OF THE COLON

SITE OF INJURY	128 COLON LESIONS IN 122 PATIENTS (ALL CASES)	99 COLON LESIONS IN 95 SURVIVORS AFTER 28 DAYS
Colon with lesions of other abdominal organs	54 (42 per cent)	39 (40 per cent)
Colon with lesions of small intestine with or without other organs	40 (31 per cent)	29 (29 per cent)
Colon with lesions of small intestine only	32 (25 per cent)	24 (24 per cent)
Colon with more than one other lesion of an abdominal organ	12 (9 per cent)	6 (6 per cent)

the cases, more than one organ in addition to the colon was injured (*Table B*). The incidence of associated abdominal injury amongst those who survived wounds of the colon is also shown (*Table B*).

The frequency of injury to other abdominal viscera in terms of the particular segment of the colon damaged is shown in *Tables C* and *D*. It will be seen that associated intra-abdominal injury occurred about twice as frequently with injuries of the transverse colon as with any other portion of the colon.

*Table C.*—INCIDENCE OF ASSOCIATED INTRA-ABDOMINAL INJURIES WITH EACH SEGMENT OF THE COLON  
(126 colon lesions ; 120 patients)

SEGMENT OF COLON INJURED	NUMBER OF LESIONS IN OTHER VISCERA	
Transverse colon 41 lesions	26 (63 per cent)	Small gut 15 Small gut and liver 1 Small gut and stomach 2 Small gut, liver, and stomach 1 Small gut and kidney 2 Liver 3 Liver and spleen 1 Stomach 1
Right Colon 40 lesions	11 (27.5 per cent)	Cæcum Small gut 3 Ascending { Small gut 2 Liver and kidney 1 Hepatic { Liver 4 angle { Kidney 1
Left colon 45 lesions	16 (35.5 per cent)	Splenic angle { Small gut 1 Small gut, kidney, liver, and spleen 1 Descending { Small gut 2 Stomach and spleen 1 Liver and kidney 1 Small gut 8 Sigmoid { Small gut and bladder 1 Bladder 1

*Table D.*—INCIDENCE OF ASSOCIATED INTRA-ABDOMINAL INJURIES WITH EACH SEGMENT OF THE COLON  
(Survivors only : 98 colon lesions ; 94 patients)

SEGMENT OF COLON INJURED	NUMBER OF LESIONS IN OTHER VISCERA	
Transverse colon 33 lesions	21 (63.6 per cent)	Small gut 13 Small gut and liver 1 Small gut, liver, and stomach 1 Small gut and kidney 1 Liver 3 Liver and spleen 1 Stomach 1
Right colon 32 lesions	8 (25 per cent)	Cæcum Small gut 3 Ascending { Small gut 1 Hepatic { Liver 3 angle { Kidney 1
Left colon 33 lesions	10 (30 per cent)	Splenic angle { Small gut 1 Small gut, kidney, and spleen 1 Descending { Small gut 1 Small gut 5 Sigmoid { Small gut and bladder 1 Bladder 1

Of the solid viscera, the liver was the one most frequently involved, and the associated colonic injury was usually in the hepatic angle or transverse portions.

In this series, the colon was damaged in more than one segment on six occasions ; 2 of these cases died.

It is of interest that fractures of the ilium occurred seven times with injury of the left colon, twice with injury of the right colon, and once with injury of the transverse colon.

**Resuscitation.**—The work of the Transfusion Units and the regular supply of blood, plasma, and other intravenous fluids were monuments to organization, skill, and thoroughness. Blood was always available and was delivered as regularly as the peace-time milk supply—only over scattered areas of the desert. As the army moved westwards after the turning point at El Alamein, the "Sign of the Red Vampire" made its appearance soon after the tanks rumbled into a fallen town.

The resuscitation service had two tasks : the first to make the wounded fit for operation, and the second to maintain fluid and salt balance during convalescence in men who were often dehydrated and deficient in sodium chloride from sweating, etc. Close co-operation between the surgeon, transfusion officer, and anaesthetist was essential for the correct selection of the case and of the time for operation.

Of 28 cases in this series in which there was marked shock requiring pre-operative blood transfusion, 25 had intraperitoneal or an extensive extraperitoneal hæmorrhage. In the remaining 3 there were other injuries which produced shock. It may be said that in uncomplicated penetrating wounds of the abdomen, shock is synonymous with internal hæmorrhage.

The wounded die in the first few hours from hæmorrhage and shock. Rapid restoration of the blood-volume, or, when bleeding is active, maintenance of the circulation until hæmostasis can be secured, is only possible when unlimited quantities of blood or plasma are available : such supplies were always at hand.

At the second battle of El Alamein 9 per cent of the casualties required transfusion, whilst at the battle of Mareth transfusion was necessary in 18 per cent—this was probably due to the greater incidence of shock-producing mine wounds. In this series the average amount of intravenous blood or plasma was 3.8 pints per patient, though much larger quantities are recorded. The largest amount in this series was 7 pints.

Plasma transfusion by Regimental Medical Officers was often possible well forward, especially in armoured formations or when there was a delay in evacuation. The difficulty of maintaining blood-volume during evacuation was overcome to some extent by arranging continuation of transfusion in the ambulance or even in aircraft.

**Operative Technique.**—As a general rule complete exploration of the abdomen can only be carried out through a median vertical incision. When damage to the fixed portion of the colon is suspected or found, much time is saved by making a separate lateral oblique or transverse muscle-cutting incision; examination, mobilization, and satisfactory exteriorization will thus be made easier.

Division of the rectus abdominis muscle above the umbilicus may be required, but, with an oblique or transverse incision, complete division of the outer edge of the rectus sheath will allow the edges of the incision to be retracted to a much greater extent.

Transverse or oblique incisions, when too near the costal margin or the iliac crest, are not only difficult to suture, but closure of a colostomy under these circumstances will be more troublesome.

The fixed portions of the colon appear to be more frequently injured from the back, and, therefore, with a penetrating wound of the flank, the wound should first be trimmed and then explored. The wound may be enlarged obliquely forwards, the abdomen opened, and the peritoneal aspect of the colon examined. Leakage from an extraperitoneal perforation is temporarily controlled, before the peritoneal cavity is opened, by means of a swab held with sponge-holding forceps.

The extent of the abdominal exploration will depend upon the pre-operative physical signs, the position of the foreign body as shown by X-ray examination, and upon the degree of hæmorrhage or soiling. In many of the cases reviewed, an oblique incision only had been used; in each case, of course, the advisability of making a further median exploratory incision must be decided.

When the abdomen has been opened through a right oblique incision, discovery of bruising or injury to the jejunum, its mesentery, or left portion of the omentum will demand exploration of the left side of the abdomen and/or pelvis. Evidence of injury to the terminal ileum, its mesentery, or the right omentum, when seen through a left oblique incision, will indicate the need for examination of the right side of the abdomen and pelvis. An additional midline incision may, therefore, be necessary to complete the examination of the abdominal contents.

The insertion of a dry swab on a holder into the pelvis, though apt to mislead, may sometimes be justifiably used as a means of assessing the probability of intra-abdominal injury in a very ill patient. The escape of gas or a faecal odour is an important observation.

Decision on the best line of treatment must not be made before complete assessment of all the damage: with multiple lesions of the gut each may be marked with forceps for rapid identification. Localized paresis and distension of a loop of small intestine are usually associated

with injury to this portion of the gut. Exploration must be quick and methodical; hæmorrhage demands examination of the solid viscera first and must be controlled before further exploration.

When the wound of entry is far back in the thickness of the loin, if its exploration does not quickly give a clue to the extent of the injury, the abdomen should be opened through a midline incision.

**Treatment of the Injured Colon.**—Though, in the past, colostomy for wounds of the colon has shown a higher mortality rate than suture, it must be remembered that this method had usually been employed in cases with extensive damage to the bowel. Exteriorization of the damaged portion of the colon, when possible, is the safest procedure. A temporary faecal fistula is of little consequence if life is saved. In the mobile segments of the large intestine this is easy and may be quickly accomplished. If circumstances permit, fixed portions should be mobilized and brought outside the peritoneal cavity. Though it is better to bring the gut out through the skin, in urgent cases with a short loop, extraperitonealization may be achieved by suturing the injured colon to the parietal peritoneum; the abdominal wall should not be completely sutured.

When the condition of the patient is such that the risk of mobilization is too great or is impossible, closure of the perforation, using two layers of sutures, together with its complete exclusion by a proximal colostomy is the next best method. The colostomy must have a good spur and should be established as near the lesion as possible; the sutured area should be drained thoroughly. Where the lower third of the pelvic colon is involved, adequate exposure and suture are difficult, and drainage and proximal colostomy alone may have to suffice. The value of local sulphadiazine, especially under these circumstances, appears to warrant its continued use. At the end of the operation 10 g. of sulphadiazine in suspension are injected through a catheter placed down to the infected area (*see below*).

A grossly bruised and devitalized area of bowel should also be treated as a penetration, since not only is there sometimes difficulty in outruling a perforation, especially when extraperitoneal, but there is also danger of delayed perforation resulting from necrosis of the bowel wall due to thrombosis.

Extraperitoneal perforation, especially of the fixed portions of the colon, may easily be overlooked. Mobilization of the colon for inspection of its extraperitoneal aspect is indicated when there is extraperitoneal bruising or gas, or evidence of injury in the immediate vicinity. Such a lesion in the fixed portion of the colon may be shut off from the peritoneal cavity by suturing the bowel to the parietes or very rarely by using a flap from the incised posterior parietal peritoneum to cover the sutured hole in the colon; good drainage must be provided.

By wide mobilization, extensively tattered segments can be exteriorized and removed. Gross tearing of the colon carries a poor prognosis owing to widespread soiling and hæmorrhage. In two cases in this series the colon (1 ascending and 1 descending) was torn so extensively that colectomy had to be performed: both cases died. When a large segment of the colon has been sacrificed, the two colonic stomata should be brought out independently at the most convenient sites. Primary anastomosis is unsound, but, after removal of a hopelessly damaged right colon, a lateral ileo-transverse colostomy, leaving the proximal end of the transverse colon open as a terminal colostomy, may be justifiable.

The retroperitoneal tissues, especially when bruised and hæmorrhagic, are very liable to spread of infection; dissection in this plane, therefore, must be the minimum required for mobilization of the damaged colon. Sulphathiazole powder or sulphadiazine suspension should be used and a separate stab drain is best inserted.

A colostomy can always be closed, but a long slack loop with its limbs tacked together will make closure easier and safer. For this reason, the perforation should be placed at the apex of the loop, when possible. A lesion of the right or left portion of the bowel is extra-peritonealized through a separate laterally placed oblique incision, since the loop will then lie more snugly. The thicker the abdominal musculature around a colostomy, the better; the transverse colon should be brought out through the rectus muscle and not through the midline. The same desiderata hold good for a proximal colostomy, which should always be opened at once.

**Post-operative Care.**—Constant, intelligent, and thorough post-operative care is only possible if evacuation is postponed until there is not only cardiovascular stability, but complete restoration of normal gastro-intestinal activity with a satisfactory fluid and salt balance. The average time the patients were retained before evacuation in a series of 95 patients was 13·5 days.

The main essentials in post-operative care are control of fluid and salt balance by continuous intravenous therapy, decompression of the gastro-intestinal tract by suction through a duodenal tube, morphia for rest of mind and intestine until the joyful tinklings of awakening alimentary activity are heard, and also chemotherapy.

#### Complications following Operation.—

**Extraperitonealization** (74 cases).—In this series of wounds of the colon, the damaged area was exteriorized on 71 occasions for penetrating wounds, and 3 times for non-penetrating injury.

Eight cases died of hæmorrhage or shock and multiple injuries within 48 hours of wounding; 1 case died of peritonitis on the sixth day; and 1 case died of pneumonia on the ninth day.

In the remaining 61 penetrating wounds exteriorized there were the following complications

directly associated with the abdominal wound and operation:—

#### Infection:—

- 1 pelvic abscess.
- 3 retroperitoneal abscesses (2 deaths after seventh week).
- 1 proctitis due to wound of lower pelvic colon.
- 1 low-grade peritonitis (death eighteenth day).

#### Intestinal obstruction:—

- 1 due to small loop around colostomy in eighth week.
- 1 due to adhesions (death seventh week).
- 1 case died 10 days after wounding from pyæmia (? infective endocarditis).
- 1 case died on the eleventh day with jaundice and enlarged liver following blood transfusion.

There were 3 cases of multiple wounds of the colon which survived following exteriorization:—

- 1 separate exteriorization of wounds of the transverse and descending colon.
- 1 exteriorization of the whole ascending and proximal transverse colon for wounds of both portions.
- 1 exteriorization of the whole descending colon, splenic angle, and distal transverse colon for wounds of descending and transverse portions.

**Suture and Proximal Colostomy or Cæcostomy** (17 cases).—Of the 17 cases recorded, 5 were non-penetrating. Of the 12 penetrating injuries, 2 died within 48 hours. Among the 10 remaining, there were the following complications directly associated with the abdominal wound and operation:—

- 2 subphrenic abscesses (1 death in 24 hours).
- 2 infection of the abdominal wall and faecal fistula (1 death in 3 weeks).

**Suture only With or Without Drainage** (23 cases).—Of the 23 cases recorded, 5 were non-penetrating. Of the 18 penetrating wounds, 3 died within 48 hours. Amongst the remaining 15 penetrating wounds, there were the following complications directly associated with the abdominal injury and operation:—

- 2 intra-abdominal abscesses—1 subphrenic (death on seventeenth day).
- 2 infections of abdominal wall—1 case with recurrent burst abdomen.

(It is of some interest that in one case with a non-penetrating colon wound, the left common iliac artery had been ligatured; the whole limb survived. The surgeon had injected the lumbar chain with novocain whilst the abdomen was open. The writer saw this case at the Base some months afterwards with evidence of vascular insufficiency—weakness, wasting, and claudication; a left lumbar ganglionectomy was performed.)

**Colectomy** (2 cases).—Colectomy was performed twice for extensive tearing of the ascending and descending colon. Both cases died.

*Drainage only* (5 cases).—

- 1 for peritonitis following a G.S.W. which had produced gas gangrene of the cæcum. The time-lag was 3 days (death).
- 2 for perforation (?) of the cæcum.
- 1 for perforation of the ascending colon. Developed a subphrenic abscess.
- 1 for extraperitoneal perforation of the ascending colon after a time-lag of 10 days—associated pyopneumothorax.

In reviewing these complications, the incidence of local infection following the various procedures is as follows:—

In 61 penetrating wounds treated by exteriorization, there were 6 instances of infection, mainly localized and intra-abdominal (3 deaths).

In 10 penetrating wounds treated by suture and proximal colostomy, there were 2 intra-abdominal abscesses and 2 infected abdominal wounds (2 deaths).

In 15 penetrating wounds treated by suture, with or without drainage, there were 2 instances of intra-abdominal abscess (1 death) and 2 instances of infection of abdominal wound.

In 5 penetrating wounds treated by drainage only there was 1 subphrenic abscess.

The risk of intra-abdominal infection appears to be increased when exteriorization is not performed, though intestinal obstruction does occur in association with a colostomy on rare occasions.

**Diaphragmatic Hernia.**—Diaphragmatic hernia with acute obstruction of the colon was reported in 2 cases, five months and three years respectively after wounds of the lower chest. In both these cases there had been an uneventful recovery, but later recurrent attacks of undiagnosed upper abdominal pain had occurred before complete obstruction supervened; both died.

It is wise during convalescence to investigate the integrity of the diaphragm in patients who have suffered wounds of the lower chest or possible abdomino-thoracic injury, especially when unexplained recurrent abdominal symptoms are present.

**Closure of Colostomy.**—The advisability of closing a colostomy depended directly upon the military situation, the available shipping, and, to some degree, upon the length of the sea evacuation route.

A total of 28 colostomies was closed, 17 of these at the Middle East Rectal Centre. In 14 cases sulphasuxidine 20 g. in 24 hours was used pre-operatively and post-operatively, and, when in short supply, sulphaguanidine 3½ g., and sulphathiazole 1 g., were given four-hourly for four days before operation. The majority were closed by means of an enterotome, followed by extraperitoneal mobilization and suture. There were no complications, and very little wound infection, though a few wounds discharged a small amount of faeces for a day or two; all healed well within 10 days.

Latterly the attention of forward surgeons to primary operative details, when justifiable, made

closure easier. Some difficulty was experienced when the artificial anus was tucked up under the costal margin or was near the iliac crest, or when there was persistent wound infection with a deficiency in the abdominal parietes or associated osteomyelitis of the ilium or ribs.

One officer, repatriated from Italy, reported that he had suffered a deal of discomfort from attempts by Italian surgeons to "reduce" his colostomy in spite of a good spur!!

A number of soldiers returned to duty in the Middle East after closure of colostomy.

**Sulphonamides.**—There can be no doubt of the value of these drugs in the control of infection. It has been the practice of the forward surgeon to place 10 g. sulphadiazine suspension into the peritoneal cavity after operation.

The sulphadiazine suspension is prepared by making a 20 per cent suspension of sulphadiazine in a filtered 3 per cent solution of best gelatine in normal saline (i.e., 10 g. of sulphadiazine in 50 c.c.). It is sterilized for 20 minutes at 20 lb. pressure.

The suspension is injected down a catheter placed into the pelvis, the catheter being then sealed with a spigot.

Absorption takes from four to five days and post-mortem examinations have shown that there is very little local peritoneal reaction to this substance.

Unfortunately, many of the notes available have not given full details of sulpha therapy. Only 84 of the cases analysed had records of sulpha drugs—63 local and 21 general—so that it is difficult to give any convincing evidence of their value when used locally in injuries of the large bowel and rectum.

It is seen, however, that in 17 cases surviving penetration of the colon, after a time-lag of 12 hours, 10 had sulpha therapy (8 local sulphadiazine, 2 general sulphonamides): probably a higher proportion had local sulphadiazine, though no mention was made in the notes.

Further, in the 8 cases surviving after a time-lag of 24 hours, 6 had sulpha drugs (5 local sulphadiazine, 1 general sulphonamide). Of the remaining 2 cases in which no record of chemotherapy was made, 1 was an extraperitoneal hæmatoma of the ascending colon which did not form a faecal fistula for several days following simple drainage.

Though there is no direct evidence of the value of intraperitoneal sulphadiazine, it is probable, in cases with a long time-lag, that it played a part in recovery.

## SUMMARY

1. A total of 128 wounds of the colon, mainly in survivors, are analysed.

a. The right, transverse, and left colon appear to have been injured with equal frequency.

b. The cæcum and transverse colon were most commonly injured by missiles entering from the front, whereas wounds of the fixed

portions of the colon—ascending and descending colon, and flexures—were usually damaged from the back. The sigmoid colon was injured from below, the front, and from the back.

c. Entry wounds in the lower quadrants of the abdomen involved the colon most frequently.

2. The relationship between time-lag, site of colon damaged, and recovery is discussed. Though the number of survivors was approximately equal for each segment of the colon injured, there was a marked fall in the number of survivors with wounds of the transverse colon operated upon after the first 6-hour period.

3. Although, in penetrating wounds of the abdomen, the organ most commonly injured is the small intestine, the incidence of wounds of the colon is also comparatively high: the

relative frequency of wounds of the small intestine to colon being 7 : 5.

With wounds of the colon, associated intra-abdominal injury occurred in 42 per cent and was most frequent with injury of the transverse colon (63 per cent).

4. In uncomplicated wounds of the abdomen, shock is synonymous with internal hæmorrhage.

5. Operative approach and treatment of the injured bowel are discussed.

6. Complications following various operative procedures are shown. Closure of colostomy is briefly considered.

#### REFERENCES

- Ogilvie, W. H. (1944), "Abdominal Wounds in the Western Desert", *Surg. Gynec. Obstet.*, March.  
Buttle, G. A. H., personal communication.

## PLASTICITY OF BONE\*

BY PROFESSOR JAMES F. BRAILSFORD

IN that part of his lecture on "Diseases of Bones and Joints", which deals with rickets, John Hunter stated, "The bones are often bent by mechanical pressure of the body and by muscular actions, into very peculiar forms and often impede the actions of other parts. The joint forms a more acute angle than it would in health, and then the muscles get a greater power of action. It is most frequent in the back-bone, pelvis, and thigh bones, in the angle made by the cervix femoris, knee, tibia, etc. In these it is most frequent, from the two powers acting (viz., weight and muscular action). The ribs are made straight, or rather bent inwards by the pressure of the atmosphere, so that the child can hardly breathe: a bad formation of the skull will affect the senses: crooked spine will affect the health from an alteration in many of the viscera. In the female pelvis many dreadful consequences occur in delivery. When a bone has admitted of a bias, a disposition takes place on the side unnaturally pressed, for a deposition of bone, so that we find a bony substance formed there which acts as a prop . . . in the thigh the curve is generally forwards towards the upper part, as was seen in an os femoris in which Nature had deposited a quantity of earth on the concave part". In a later part of the lecture which deals with dead bone, he states, "The first effect of the stimulus is on the surface of the living bone, which becomes inflamed: whether new vessels are formed, or the old ones become larger, is undetermined; but by injecting the surface of the part, it appears evidently much more vascular than the other parts. This produces another process. First, absorption of the earthy matter,

and all the surface between the living and dead parts of the bone become soft as if steeped in acid, while the dead part remains as hard as ever". In these two brief extracts you have the gist of my paper. My contribution is largely but a confirmation, with the aid of an accessory which Hunter had not, namely X rays, of the observations which he made during clinical investigations. My excuse is that it permits me to emphasize one small part of his teachings which would appear to have been neglected in the employment and dependence on modern ancillary devices, and the neglect of those clinical investigations from which Hunter learnt so much. Used in their proper place, as one can imagine Hunter would have used then, these ancillary services can often help to confirm or dispute theories suggested by clinical investigation.

**Features of Normal Bone.**—The histologist, Reichert, promulgated the concept that bone, cartilage, tendon, fibrous, elastic, and adipose tissue, derived from the mesenchyme, are all adaptations of or developments from the primitive connective tissue. Subsequently Leriche and Policard brought forward evidence in support of their suggestion that these mature tissues may be induced under certain influences to revert to their primitive state and then undergo ossification. They consider it is only in this way that cartilage or membrane is substituted or transformed into bone. The embryonic connective tissue consists of cells in a collagenous matrix, composed of a fine fibrillar network infiltrated with a very viscid, gelatinous base. The impregnation of this matrix with phospho-calcific mineral matter permits of the setting of the matrix and the formation of bone. The part which the bone-cell takes in these activities has been a matter for considerable discussion. While

\* Being a Hunterian Lecture delivered at the Royal College of Surgeons of England on April 26, 1944.



by some it is thought, either by its secretion or by its degeneration, to be the origin of the pre-osseous substance, by others it is assumed that the latter results from physiochemical changes in certain pre-existing connective-tissue elements while the cell exhibits little but osteolytic characters. The normal shape of the skeletal elements is laid down in the primitive mosaic and it has been shown experimentally that, even if these are separated and then cultivated, they develop their general characteristic features. Though the arrangement of the cancellous trabeculae and the prominence of muscular attachments are modified by function, the general features of the perfect model are preserved by the balance of muscular tension and the strength, hardness, rigidity, and resilience of the bone. The features are changed if the balance is upset, when the relative stresses and strains are diminished or increased relative to the elasticity and strength of the bones. As a result the affected elements bend and certain characteristic deformities are produced unless steps are taken to neutralize the abnormal influence. Normal bone possesses a balance of strength, hardness, elasticity, and rigidity which is determined by the solidity and form of its structure, the condition of the fibrillar base, the comparative amount, cohesion, nature, and condition of its matrix, and the calco-phosphate mineral elements which it holds together.

Prior to the deposition of mineral matter the pre-osseous tissue is plastic and can be compressed and deformed by stresses and strains—the lasting effect of which will be dependent upon the time for which they are continued, the changes wrought in neighbouring tissues, and their shape and position at the time setting of the matrix takes place. With the deposition of crystalline salts of calcium, such as we see in calcification, no material contribution is made to the rigidity or strength of the bone. We see this (Brailsford, 1943) in the skeleton in foetal osteogenesis imperfecta where all the bones show a granular appearance and multiple foldings indicating a lack of cohesion of the mineral elements—a friability rather than a plasticity. This feature is also seen in one stage of avascular necrosis of bone where the dead fragment collapses or even crumbles within its cartilaginous or membranous envelope. On the other hand, with the incorporation of colloidal calco-phosphate mineral matter, the pre-osseous matrix appears to undergo a rapid setting which may be likened to that of reinforced cement and the bone acquires a rigidity, resilience, and a relative fixation of form which is unaltered by normal function. Normally ossification commencing in an ossific nucleus, spreads uniformly and gradually from the regular centre to the periphery of the cartilaginous mass. It is not deformed by the normal stresses and strains of function of the growing child.

**Effect of Irregular Ossification.**—If, however, the ossification in any site is irregular and

multiple irregular ossific centres develop throughout the cartilaginous structure, this structure will not be capable of withstanding normal function, and, because with the irregular deposition of mineral matter it has lost its elasticity and taken on the characters of a plastic substance, it can be compressed and deformed. Examples of this (Brailsford, 1944) can be seen in hypothyroidism. In the foetus and young infant with this deficiency the ossification of the vertebral bodies is irregular and the keystone of the general spinal curvature, which is in the dorso-lumbar area, may collapse, resulting in stunted growth of the affected body and the development of a kyphosis; while in the older child the femoral capital epiphysis, which exhibits a similar defect in ossification, is splayed out over the upper end of the diaphysis so as to resemble the appearance of healed or healing Legg-Perthes' disease or deformed into the beak shape which is most commonly seen in cretins. In the condition to which I gave the name *chondro-osteodystrophy*, we also have multiple ossific nuclei; consequently in this disease primary and secondary centres of ossification will be deformed according to the pressures or muscular strain to which they are subjected during the irregular incomplete phase of ossification. In a later portion of the paper more attention will be paid to similar deformities of the skeleton due to localized plasticity induced by trauma or disease.

### INFLUENCE OF PARALYSIS ON THE SKELETON

With the cessation of function occasioned by paralysis there occurs a gradual decalcification of the bones of the affected part; eventually all the cancellous tissues within may be absorbed and the compact cortex considerably reduced in thickness; yet with the patient immobilized little change occurs in the outward form or position of the bones. Compared with the opposite normal limb a concentric atrophy of the shafts may later be seen which is emphasized by the more normal sized extremities. The spine under those circumstances is not subjected to defective balance and the normal curvatures are more or less preserved. With the patient up and about with one paralysed lower extremity, the bones of the latter appear to be affected by a gravitational pull. The angle of the femoral neck with the shaft is straightened out and dislocation may occur (Brailsford, 1944). The os calcis and other bones of the foot also show the effect of gravity. Scoliosis of the spine may occur, but the most marked cases of moulding associated with abnormal curvature have developed in children following one of the exanthemata of childhood. Soon after recovery from, say, an attack of measles, a slight curvature of the spine is noticed. The radiographs at this time may show curvature unassociated with any secondary moulding. With the alteration in balance, possibly associated with an undue weakness of the

spinal musculature, the curvature progressively increases in spite of fixation in the spinal jacket. The vertebral column with its processes and ribs undergoes very considerable moulding and the most extreme form of deformity may ultimately result.

The following is an example of this type of case:—

M. B., female aged 6, in 1927 was found to have a left dorsal scoliosis, the lower curve of which appeared to be corrected by suspension (*Fig. 273*). She was put into a plaster case and in 1929 her report



FIG. 273.—Scoliosis in a girl aged 6 years (Sept. 12, 1927) which appeared to be corrected by suspension.

card stated that "it appears to be holding her well". On Jan. 30, 1929, the general alinement of the body was noted as good. On Aug. 14 plaster was removed and a note stated that the deformity was not increasing. Block leather support with double crutches were provided, and on Oct. 8, 1930, the report states: "Is standing better now"; on Nov. 9, 1932, the report states deformity stationary. Similar reports continue to record the clinical findings, but examination of the series of radiographs taken regularly since the condition was first recognized show a progressive development of the deformity and now the curvature is so extreme that the upper border of the 11th dorsal vertebra is on the same plane as the lower border of the 3rd (*Fig. 274*).

The progressive development of this extreme form of curvature indicated that neither the plaster case nor the block leather supports were able to check the deformity. Immobilization in bed during the early stages, perhaps for two

years, with exercises, may correct the balance and so prevent the progressive development of the curvature.

### PLASTICITY DUE TO GENERALIZED CHANGES IN THE BONE

Those cases of osteogenesis imperfecta which survive birth and live to adolescence or adult life show in the early months and years a skeleton rather lacking in density but otherwise of normal shape and size. Depending on the gravity of the disorder, we see the development of changes (Brailsford, 1943). More pronounced than in the paralysis, we see a concentric atrophy of the shafts of long bones, while the diaphysial extremities appear to be markedly expanded by



FIG. 274.—Same patient as *Fig. 273*, 17 years later. Note the very considerable advance in the deformity and moulding of the ribs and spine

their normal development. At this stage the skeleton exhibits a marked plasticity and develops deformities, the extent of which in any part are dependent upon the gravitational and muscular pulls. The head takes on a tam-o-shanter form with its vertex and sides tending to gravitate over the base—the latter tending to fold over the upper part of the spine. The vertebral bodies are compressed to half or one-third of their depth—though the discs preserve or even appear to exceed their vertical dimensions.

The vertebral epiphyses appear to be activated to earlier ossification, so that ossific nuclei may be readily demonstrated in them as early as the sixth year. The ribs show a marked gravitational bending: from their necks they become sharply directed downward. The bones of the upper extremity may almost or entirely escape in the lesser degrees of the dystrophy, but in the severe

forms the shafts of the long bones are slender and exhibit bending due to the superincumbent weight on the plastic bone during crawling. But it is in the lower extremity that we see the major deformities of the plastic bone. The pelvis may be so plastic that it is compressed and distorted



FIG. 275.—Marked plasticity of bones in infantile rickets.

by the multifarious gravitational and muscular pulls until it assumes a wind-swept appearance. The femora exhibit large extremities composed of wide-mesh cancellous tissue with but a thin periphery, while the shafts gradually become slender rods of compact bone (Brailsford, 1944). In their earlier stages of development such shafts are relatively brittle, but later, bending, in spite of muscular atrophy and an increased proportion of compact relative to cancellous tissue, indicates a degree of plasticity of the bones. So deformed may these plastic bones of the lower extremity become that the limbs are functionless, and their encumbrance has caused the surgeon to consider amputation advisable. In the less severe degrees of the dystrophy condensation of bone may occur at the apex of the curvature—Nature's attempt to limit it. In the active phase of infantile rickets the bone is lacking in mineral matter and all ossification is irregular, so that a considerable degree of plasticity of the bone exists which permits of bending and compression deformity of all parts of the skeleton by stresses and strains which would not affect normal bone (Figs. 275, 276). With healing of the condition Nature attempts to correct the deformity or prevent its greater development by buttressing the concave

aspects of the curvature with stout compact bone, as recorded by Hunter. The deformities which occur in infantile rickets are copied in the adult skeleton with the development of osteomalacia (Brailsford, 1944), but in this adult condition the deformities become more profound owing to the increased stresses and strains to which the adult skeleton is subjected.

In the rickets associated with renal fibrosis, two types of change are seen (Brailsford, 1944). In *Type A* the bones appear to preserve their strength except at the metaphyses—these may disintegrate under pressure and permit of serious displacement. In *Type B* there appears to be an added factor, probably associated with hyperparathyroidism, since in all such cases one has found at post-mortem hypertrophy of all the parathyroids; this leads to softening of all bones; they become so plastic that extreme degrees of gravitation deformities may develop, and though the metaphyseal areas exhibit an even greater destructive change than in *Type A*, these sites are not subjected to the displacements we see in *Type A*.

In hyperparathyroidism associated with a parathyroid tumour a profound decalcification of the skeleton ultimately occurs, leading to marked pressure deformities, but, except in young persons, as the condition of the patient before marked plasticity occurs has been reduced



FIG. 276.—Pressure deformities of the plastic bone of the pelvis and femora in infantile rickets. The active phase has passed.

to almost complete invalidism following multiple fractures and general weakness, the gravitational deformities seen in osteomalacia are not usually present. The type of decalcification in the earlier phases is distinctive (Brailsford, 1944) and its recognition of the utmost importance for early diagnosis before deformity or fracture occurs. Though in the latter stages it is associated

with destruction of large areas of cancellous tissue and the production of multiple cyst-like structures, which has earned for it the title 'osteitis fibrosa cystica', in the earlier stages these cyst-like areas may not be found—there may be but a stippled osteoporosis of the bones with perhaps small areas of ill-defined cancellous absorption.

### PLASTICITY DUE TO CHANGES WHICH MAY BE LOCALIZED TO ONE AREA OF THE SKELETON

The most notable of the conditions in which plasticity is exhibited originally in one bone, while all other parts of the skeleton may be normal, is Paget's disease. Unfortunately, the novice who has not mastered Paget's description of the disease, which he called 'osteitis deformans', is apt to interpret the radiographic appearances of hyperparathyroidism as Paget's disease. This has resulted in very serious delay in diagnosis of a condition which, diagnosed early, can be treated with success, but which, after the crippling effects of fractures and invalidism, yields a relatively poor result to treatment. Hyperparathyroidism is essentially a generalized condition from the first, whereas Paget's disease begins as a localized condition. Paget's description of the condition should be reproduced in all text-books (Brailsford, 1944), for though he was, perhaps fortunately, without the aid of radiography and more recent laboratory investigations which appear to detract attention from the patient, his clinical observations were so accurate and exhaustive that little addition has been made to our knowledge by the more recent developments.

Radiographic study of the skeleton in Paget's disease reveals that the condition may commence in one bone or in several widely separated bones. It may commence as a subperiosteal change which on the radiograph in the early stage is represented as a lanceolate cyst-like absorption of an area of the cortex of a bone which is elsewhere normal—the line of demarcation between the Paget lesion and the normal bone being fairly sharply defined; progress of the lesion is indicated by stripping up of the periosteum by a V-shaped thrust into the normal tissue.

When the whole periphery of the bony segment has become involved the normal compact cortex within is gradually absorbed and the bone develops an increased plasticity which permits of bending under ordinary physiological strains. Gradually the whole bone is changed. The rate of progress may be so slow that it may be 10–15 years before the whole bone is involved. This is important from a medico-legal aspect when the patient alleges that the limb was normal until a recent injury. The disease may remain localized to the one bone for years, or it may then spread across the joint and involve adjacent bone without producing any appreciable alteration in the articular surfaces. In one case

one rib was involved and the disease involved its vertebra and then its fellow on the opposite side—the other bones remaining normal. In the same patient the disease may commence in another bone as a localized endosteal change—here the cancellous spaces appear to be filled up with a mineral deposit giving the bone greater and uniform density. In the smaller bones and the flat bones all distinction between compact and cancellous tissue may be lost in the uniform density, but in the larger tubular bones like the femur a thickened cortex may give the bone the appearance of marked hypertrophy. Such changes may occur without attracting the serious attention of the patient, i.e., serious enough to seek radiographic examination.

I have shown (Brailsford, 1944) that the radiographic appearances of Paget's disease may exhibit three distinct types of bone changes. To these I have given the names (1) Osteoporotic, (2) Osteolithic, (3) Lithocystic. The first type shows general expansion of the bone, osteoporosis, coarse trabeculation, and bending under normal physiological strains. In the acute phase the bone is plastic and marked bending may be unassociated with any breach of the surface, but complete fracture may occur during simple unguarded movements. At a later stage the long bones exhibit the reaction to strain which we see in a banana when its curvature is increased by pressure. The concave aspect is condensed while the convex aspect shows one or multiple fissures running towards the centre from the periphery, i.e. incomplete fractures.

The osteolithic bone is much denser than normal and of stouter build, and though it gradually bends under continuous physiological strain it exhibits an abnormal fragility and may snap like a stick of chalk with trauma insufficient to damage normal bone; during the following 2–3 weeks it may develop acute halisteresis. This form is simulated by carcinomatous infiltration of the bone from primary carcinoma of the prostate, stomach, or oesophagus, though in these, because of the more rapid reaction, condensation of the bone is not associated with the degree of plasticity and consequent expansion and deformity seen in Paget's disease.

In the lithocystic form, which in its early stage may show marked decalcification, the affected bones eventually exhibit massive development with thickening of the dense cortex, within which cyst-like areas of various sizes without cancellous trabeculation may be recognized. In spite of the massive build of these bones considerable bending may occur and transverse fracture may occur as with the osteolithic type. The disease not only involves the normal bones, but ossified ligaments, massive repair bone at the site of old injury or old inflammatory foci, and ectopic bone in the soft tissues, develop the Paget characters of adjacent bone. In many cases biopsy has been performed to establish the diagnosis, but nothing has been added in

all these years to the description of the histological appearance included by Paget. Far more can be learnt of the condition by careful periodical X-ray examinations of the skeleton. The more attention we pay to these serial radiographic studies the more readily we can anticipate the histological appearances. I feel that this is the method which Hunter would have used. Even without the urge of use of the multifarious ancillary services which we have to-day, Hunter's experience caused him to state, "It is astonishing to see what little curiosity people have to observe the operations of Nature, and how very curious they are about the operations of Art."

There is a condition called by Elmslie 'fibrosis of bone', or more recently by Lichtenstein and Jaffe 'polyostotic fibrous dysplasia', in which



FIG. 277.—Patient with generalized polyostotic fibrous dysplasia.

the skeleton of the individual gradually develops, locally or throughout its whole structure, a remarkable plasticity permitting of great deformity (Figs. 277-279). The localized lesions as they occur in the skull or long bones exhibit radiographic appearances which may be mistaken for those of simple cysts—the lesions are represented by clearly defined expanded segments of bone which are devoid of cancellous trabeculae but yet they are denser than the simple cysts. Such conditions have also been mistaken for those of hyperparathyroidism, and operative measures for the removal of parathyroid tumour have been undertaken in many cases. The distinguishing feature is that all other parts of the skeleton present the appearance of normal

bone, even that adjacent to the so-called cysts shows normal cancellous and compact tissue—there is no general decalcification. In those



FIG. 278.—Radiograph of the legs of patient shown in Fig. 277. Note marked bending of the bones.

cases which are more generalized the defective segments show whorls of chondrous tissue, with or without calcification of their peripheries



FIG. 279.—Radiograph showing polyostotic fibrous dysplasia in the one limb only.

(Figs. 278, 279). The localized areas are expanded, in the skull producing an appearance which may be mistaken for leontasia ossea, and in the long bones permitting of bending, particularly when the lesions are developed in the lower extremity.

Localized inflammatory lesions in, or in the neighbourhood of, bones, lead to decalcification and plasticity which permits of marked deformity, unless measures are adopted to prevent it. The development of coxa vara following inflammatory lesions in the femoral neck is an instance.

shown little change (*Fig. 280*). This suggests that the deformity might be prevented by immobilizing the patient during the active inflammatory phase.

As I showed in a previous paper (Brailsford, 1936), plasticity of bone may develop after union

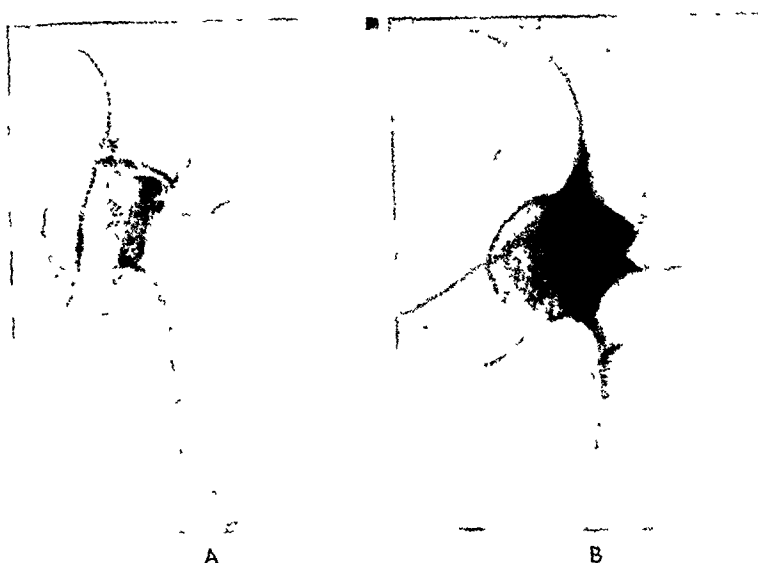


FIG. 280.—A, Protrusio acetabuli a few months after subacute arthritis of the hip-joint. B, Same hip-joint 10 years after. Consolidation of the plastic bone and no further extension in the interval.

Following trauma to the hip-joint, or as the result of inflammatory lesions in or around the hip-joint, the walls of the acetabulum become plastic for a time and if subjected to pressure during this

of fragments which had been fixed by metallic plates or pins, and the fixing screws or other fittings be torn from the plastic bone (*Fig. 281*). This reaction in the bone has been attributed to electrochemical changes between the bone and the metal. Though attempts have been made to check it by using metals considered free from this action, my radiographic experience suggests that removal of the metallic support as soon as the radiograph shows bony union between the fragments, followed by a short period of immobility, would give the better results.

#### CHARACTERISTIC CHANGES IN VARIOUS SKELETAL ELEMENTS EXHIBITING ABNORMAL PLASTICITY

It is impossible in the brief time at my disposal to do more than indicate the characteristic deformities which arise from abnormal plasticity. Their significance (Brailsford, 1944) cannot be discussed.

**The Skull.**—The most important of the pressure deformities is that referred to as the basilar impression—it is most commonly associated with Paget's disease and has been said to be associated with the carrying of heavy weights on the head.

**The Spine.**—Localized plasticity of the vertebral column as the result of injury or disease comes to be associated with compression myelitis. Scoliosis and kyphosis and kyphoscoliosis are all eventually associated with moulding and condensation of compressed bone.



FIG. 281.—Bowling of the femoral shaft in spite of plate. Screws pulled out of the plastic bone during bending.

phase will be pushed by the femoral head into the pelvis—thus is produced the lesion referred to as protrusio acetabuli. Consolidation of the protruded bone is brought about by the deposition of much mineral matter, and unless the inflammatory reaction persists the deformity is stabilized. Observations of such cases over 10 years have

Biconcave compression of the vertebral bodies, until they simulate fish vertebrae, with relative expansion of the discs, is seen more commonly in osteogenesis imperfecta, the various types of rickets, osteomalacia, and hyperparathyroidism.

**The Pelvis.**—Besides the complicated distortions of the plastic pelvis such as we see in osteogenesis imperfecta, Paget's disease, and osteomalacia, localized sites of osteochondritis occur in the neural arch of the 5th lumbar. This may be associated with the progressive deformity of spondylolithesis, as was seen in the specimen which used to be in the Hunterian collection. Protrusio acetabuli, as we have seen, is due to gravitational strain on the head of the femur, against an acetabulum the pelvic wall of which has been softened as the result of post-traumatic inflammatory changes and subacute arthritis—particularly post-menopausal arthritis. It also occurs in Paget's disease of the pelvis.

**Limb Bones.**—The chief deformities of the limb bones are those associated with an increase in the curvature producing alterations in the normal angles of the bones and joint surfaces.

### CONDITIONS ASSOCIATED WITH REDUCTION OF NORMAL BONE ELASTICITY

In Albers-Schonberg's disease, certain forms of Paget's disease, and secondary carcinomata of the skeleton, though the affected bones are abnormally dense from their increased mineral content, they appear to have lost the characters associated with normal fibrous bone and transverse fractures occur as the result of trauma insufficient to fracture normal bone. In tabes dorsalis, though the bones appear to be of normal radiographic appearance, they often exhibit an unusual fragility and comminuted fractures occur; the lack of muscular protection is probably a feature in these cases (Brailsford, 1941).

### LOCALIZED PLASTICITY OF BONE DUE TO TRAUMA

When a bone is subjected to persistent abnormal strain, reactive inflammatory changes are incited, localized softening of the bone occurs, and pressure deforms the plastic bone. This phenomenon is seen more commonly perhaps in the spine than in any other region. In any occupation, particularly in young individuals with incomplete ossification, which necessitates continuous bending, compression is exerted on the anterior aspects of the dorsal spine. With the healthy individual physiological periodical reshuffling adjusts the tissues and no harm is produced, but in the debilitated and fatigued person such reshuffling is diminished or even abolished. Consequently the pressure becomes continuous and reactive inflammatory changes are induced in the tissues under compression. Some localized decalcification with plasticity results. Later re-ossification fixes the deformity. Continued pressure leads to condensation of the

opposing bony surfaces and ossification of the adjacent ligaments—Nature's method of checking the growth of the deformity. Any lesion, whether it be developmental, traumatic, inflammatory, or neoplastic in origin, which alters the



Fig. 282—Scoliosis with marked lipping of the vertebral bodies in the concave aspects of the curvature.

normal alinement or balance of the skeleton, will cause abnormal strains to be placed on some structure; sooner or later this will show the reactive changes detailed above (Fig. 282). With the young person no disability or reactive changes on the radiograph may be detected because of possible physiological compensations, but as the strains of adult life begin to mount, symptoms develop and serial radiographs show a progressive change. A good instance of this is the young patient who develops a pneumococcal arthritis of one hip-joint which goes on to bony ankylosis. After a year or so he has accustomed himself to the normal fixation and certain compensatory activities have developed, but in the late 20's or early 30's the opposite hip-joint, which was normal, will show abnormal moulding of the roof of the acetabulum and later some condensation of the subarticular bone. Within a few years atrophy of the superior articular cartilage will be apparent, followed by the progressive development of osteo-arthritis—a very serious surgical problem in so young a person.

### PLASTICITY AND OSTEOCHONDRITIS

Most of the secondary and some of the primary ossific centres develop the changes which have been included under the general heading osteochondritis. In the initial stages of the condition, when associated with necrosis of well-formed ossicles, the young bone develops an increased density and friability. As a result the affected bone is crushed or fragmented, but

its articular cartilage is apparently spared (Fig. 283). Later the interstices between the fragments appear to be infiltrated with living tissue which brings about gradual absorption of all the mineral matter from the fragments (Fig. 284). During the whole of this phase the affected bone is plastic and can be deformed by pressure from adjacent bones. But the necrotic fragment is not the only bone which is affected. Reactive inflammatory changes occur in the adjacent living bone. It is decalcified, apparently at the expense

immobilization. For the condition known as Legg-Perthes' disease I draw up the following time table from a study of the serial radiographs of a large group of cases.



FIG. 283.—Active plastic phase of Legg-Perthes' disease of the femoral capital epiphysis.



FIG. 284.—Same patient as in Fig. 283, fifteen months later, showing further compression of plastic bone and some absorption of calcium.

of the dead fragment, and it also becomes so plastic that it can be deformed by pressure. As the dead fragment is progressively decalcified and reconstituted, the adjacent bone recovers its calcium and normal characters, but any

It shows that for upwards of 3-4 years the bone exhibits abnormal plasticity. Until the last dense island has been absorbed this plasticity will permit of deformity by pressure. In certain other sites, such as the infant scaphoid and the

#### ONSET OF RADIOGRAPHIC APPEARANCES IN LEGG-PERTHES' DISEASE

RADIOGRAPHIC APPEARANCES	AGE OF LESION JUDGED FROM ONSET OF FIRST SYMPTOMS	CONDITION OF THE BONE
1. An increase in the density of the femoral capital epiphysis	2-3 months	Becoming plastic
2. A relative increase in the joint space		
3. Osteoporosis of the diaphysis	3-18 months	Plastic
4. Compression and impression fractures of epiphysis		
5. Appearance of fragmentation		
6. Compression and flattening of fragments		
7. Gradual absorption of the dense fragments	1½-4 years	Plastic
8. Compression and expansion of the proximal end of the diaphysis		
9. First appearance of regeneration in the epiphysis in which dense fragments are undergoing absorption	During or after the 4th	Consolidated
10. Absorption of the last dense nucleus, and the appearance of a circumscribed area of osteoporosis in its place		
11. Increased deposition of calcium and obliteration of the osteoporotic zone in the diaphysis		
12. The epiphysis assumes the radiographic appearance of a normal bone		

deformity produced during the plastic stage is fixed. It will be obvious therefore that if we are to avoid deformity, and the subsequent series of changes leading to osteo-arthritis, we must protect the plastic bone from any pressure. As I have shown, the sequence of changes which such bones undergo have a time table which permits us to arrange for the necessary

vertebral body, the time table is speeded up, and within 1-1½ years the affected bone has been sufficiently reconstituted to permit of normal function. The cause for these localized lesions of osteochondrosis is not definitely known. Trauma and embolism have been suggested amongst other things. Undoubtedly trauma can produce avascular necrosis of fragments of bone.



We see it more commonly following fracture of the femoral neck or carpal scaphoid. The most important feature is that these necrotic fragments

fragment has been removed or entirely reconstituted (*Fig. 285*). It has been stated by our writer on fractures that "There is no suc

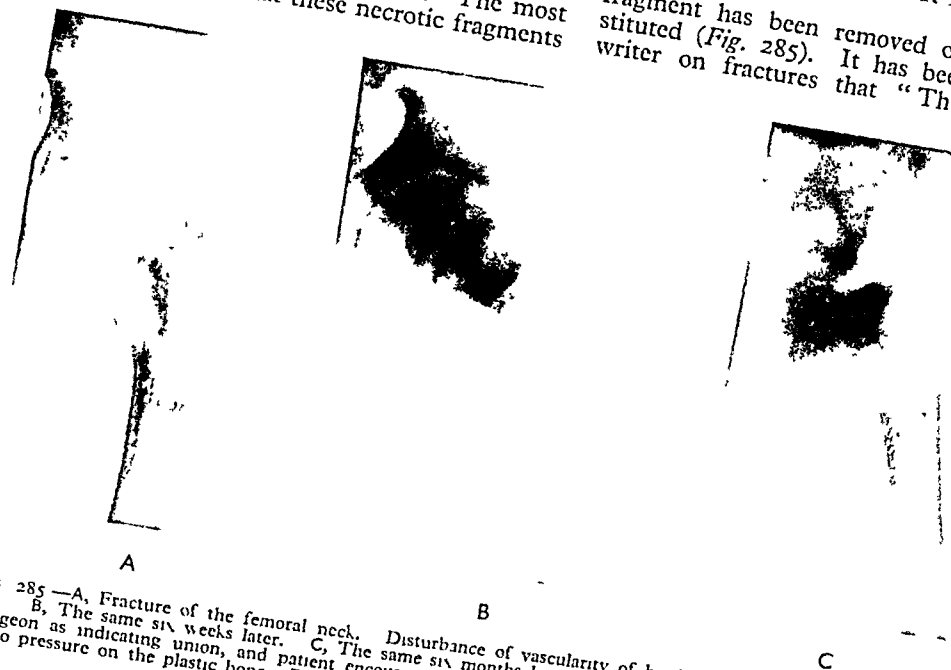


FIG 285—A, Fracture of the femoral neck. Disturbance of vascularity of head fragment is indicated by its relative density. B, The same six weeks later. Radiographs at three months were regarded by the surgeon as indicating union, and patient encouraged to use limb. Note the coxa vara deformity which has resulted owing to pressure on the plastic bone. The head fragment was reconstituted in four years. C, The same six months later.

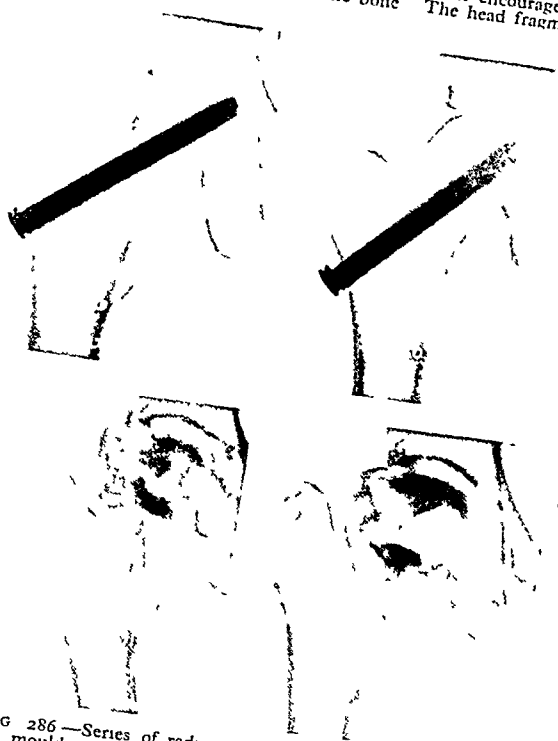


FIG 286—Series of radiographs illustrating collapse and moulding of avascular head fragment of femur.

excite inflammatory reactive changes in the adjacent vascular bone leading to its decalcification and abnormal plasticity, until the necrotic

thing as osteochondritis; it is avascular necrosis", but the radiographic evidence shows that the most important feature associated with necrotic bone is the accompanying osteochondritic reaction in the adjacent living bone (Brailsford, 1943). Failure to appreciate it has led to very many disasters following pinning of the fractured femoral neck. The fragments were adjusted as near as possible to normal alignment and held in position by a Smith-Petersen pin or other metal nail. After an interval, sometimes but a few days or weeks, or perhaps even as long as three months, the patient was allowed to use the limb (*Fig. 286*). Because the radiograph appeared to the observer to show good alignment and perhaps some union, the patient was encouraged to get the limb into full function, i.e. he was rehabilitated. Following such an injury a certain amount of pain was experienced in using the limb, but if this was mentioned, the surgeon, supported by his reading of the radiograph, explained that this was to be expected for some time. The patient gave progressively increased function to the limb and because the surgeon had indicated that he expected some pain and disability these features became so pronounced that further advice was sought. Radiographs now showed that the pin had cut through the plastic bone of the femoral head or neck or even the walls of the acetabulum, as it would

through butter, because of the superincumbent weight of the trunk on the pin (*Fig. 287*). Many disasters of this type have been used to illustrate

to four years, the necrotic fragment should be removed as soon as detected. This opinion I had formed from a study of several hundred cases



FIG. 287.—A, Radiograph showing pinning of neck of femur three months after insertion of pin. Radiograph interpreted as showing union of fragments. Function permitted. B, Same patient. Note the wide excavation of the plastic bone of the femoral neck and displacement of fragments and pin.

the changes in avascular necrosis. Similar disastrous sequelæ have followed—rehabilitation of a dislocation of the hip-joint in which radiographs three months after the injury have been erroneously interpreted as normal (*Figs. 288,*

of osteochondritis associated with and without avascular necrosis.

In the preparation of this paper I again studied the lectures of Hunter and I found he had given us the explanation from his careful

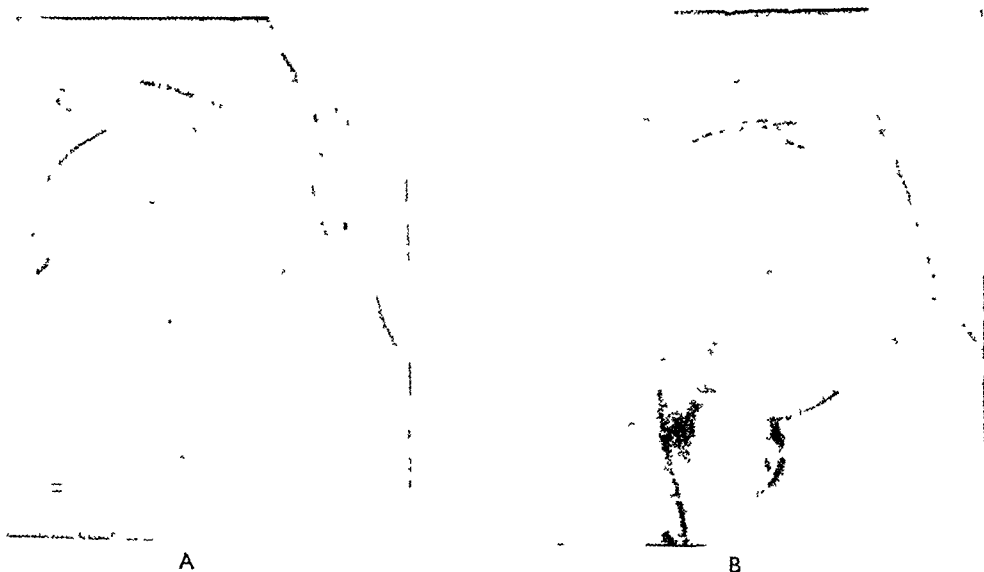


FIG. 288.—A, Reduced dislocation of hip-joint. A little calcium below femoral neck. B, Same two years after, showing disintegration. Avascular head fragment and much ectopic bone.

289). The possibility of progressive absorption in tabs should be borne in mind (*Fig. 290*).

In a previous paper I pointed out that unless the patient with an avascular fragment can submit to immobilization until radiographs show reconstitution of the fragment, i.e., upwards of three

clinical examinations. He states "When a piece of bone becomes absolutely dead, it is then to the animal machine as any other extraneous body, and adheres only by the attraction of cohesion to the machine. The first business of the machine, therefore, is to get rid of this cohesion



FIG. 289.—Marked compression deformity of femoral head and neck following surgical manipulation and reduction of congenital dislocation

and discharge it. For affecting this separation there are several natural and successive operations going on. The first effect of the stimulus is on the surface of the living bone which becomes inflamed; whether new vessels are formed, or the old ones become enlarged is undetermined; but by injecting the surface of the part it appears eventually much more vascular than the other parts. The surrounding parts also inflame, as the periosteum and cellular membrane, and often take on an ossific inflammation. This produces another process; first, absorption of the earthy matter, and all the surface between the living and dead parts of the bone become as soft as if steeped in acid, *while the dead part remains as hard as ever*. To complete the separation, the absorbents continue their office and absorb the living parts also". These findings of Hunter are confirmed by my radiographic investigations.

Had his teaching been fully appreciated, recent faulty interpretations would have been avoided and patients have been spared some of the disasters attendant upon necrotic bone.

In the question of the dead bone remaining "as hard as ever", Hunter was considering the question of the sequestrum in sepsis. In aseptic necrosis it applies only for a short time, as will be apparent from the radiographic evidence of collapse and friability of the dead fragment within a few months of its death. More recently



FIG. 290.—Progressive absorption and moulding in a case of tabes. Note the development of the Charcot's joint at the fracture site.

Leriche and Policard have stated, "Physiologically dead bone, with dead cells, seems to have the same mechanical value as when it is living.

induce reactive changes in the adjacent bone which lead to plasticity as a preliminary step to reconstitution and consolidation (Fig. 291, A, B).



FIG. 291.—Radiographs showing reconstitution, consolidation, and growth of bone-graft replacing polycystic lesion. A (May 5, 1938), Shows callus around fracture of lower third of graft (shaft of fibula) Decalcification of femoral shaft. B (June 4, 1944), Shows consolidation and growth of graft, which now equals the calibre of the femoral shaft. (Mr. A. M. Hendry's case.)

But as long as it is tolerated and as long as it is maintained in the organism, it seems to play the same mechanical part". This opinion is not borne out by radiographic evidence, for the dead fragment sequestered by inflammatory changes retains its hardness and sharpness of outline, whereas the fragments tolerated tend to undergo progressive decalcification and softening, and

#### BIBLIOGRAPHY

- BRAILS福德, JAMES F. (1943), *Brit. J. Radiol.*, May, 130.  
 — (1944), *The Radiology of Bones and Joints*, 3rd ed. London: J. & A. Churchill.  
 — (1936), *Brit. med. J.*, 2, 657.  
 — (1941), *Brit. J. Radiol.*, Oct., 320.  
 — (1943), *J. Bone Jt. Surg.*, April, 249.

## CONGENITAL DEFICIENCY OF THE PERICARDIUM ASSOCIATED WITH A BRONCHOGENIC CYST

By N. LLOYD RUSBY

PHYSICIAN TO OUT-PATIENTS, LONDON CHEST HOSPITAL; PHYSICIAN, E.M.S. THORACIC UNIT, HAREFIELD

AND T. HOLMES SELLORS

SENIOR SURGEON, LONDON CHEST HOSPITAL; SURGEON, E.M.S. THORACIC UNIT, HAREFIELD

### INTRODUCTION AND HISTORIAL SURVEY

IN the year 1788 Matthew Baillie opened the chest of a man of about 40 years and saw a naked heart lying in the left side of the chest. In reporting this case in 1793, Baillie gave the first authentic account of congenital deficiency of the human pericardium, a condition so seldom encountered that even to-day it can be truthfully described in Baillie's original words as "one of the deviations from the ordinary structure of an animal in which nature has been most sparing".

Some earlier examples of the condition have been reported, the first by Realdus Columbus

in 1559 (Curling, 1839), and others by Littre in 1712 and Vieussens in 1715. Vieussens described the findings at autopsy upon a soldier, aged 35, who had two hearts, one of which was devoid of pericardium. Upon the validity of many of these earlier case reports (which can be found summarized in the publications of Otto in 1831 and Curling in 1839) doubt has been cast by anatomists on the grounds that they were examples of diffuse adhesive pericarditis and not of genuine pericardial deficiency. Baly reported another case in 1850 in a young man in whom autopsy

disclosed the heart lying in the left pleural cavity invested by the visceral pleura. Four years later Bristowe (1854) published another case of a male aged 28 in whom the heart and left lung occupied a common serous cavity. Peacock, in the second edition of his *Malformations of the Human Heart* (1866), was familiar with the publications of Baillie, Curling, and Baly cited above, and had himself observed an example in a man aged 75 who had died of aortic valvular disease. The heart lay in the left pleural cavity adherent to the left lung. In contrast to the foregoing examples of complete absence of the pericardium, Powell in 1869 recorded the interesting finding of a partial deficiency. The patient died from spontaneous pneumothorax on the left side, and post-mortem examination disclosed air not only in the pleural space but in the pericardium also, the two serous sacs communicating through a small opening with a smooth edge lying above in the left lung root.

During the next 40 years other cases were placed on record, and Ebstein in 1910 compiled 32 examples up to that time. In 1925 Moore undertook a comprehensive study of the available medical literature and collected 64 recorded cases, obtaining access to the protocols of 42 of them. They had all been discovered accidentally at autopsy.

A careful search of the literature since the publication of Moore's paper has brought to light 15 further examples occurring in man, all of them, with 2 exceptions, being chance findings post mortem. These two exceptions have been provided by Ladd (1936) and Dahl (1937). Ladd operated upon a left-sided diaphragmatic hernia in a 2-year-old girl, using an abdominal approach. Through the hole in the diaphragm he saw that the heart was without a pericardium, but the existence of a rudimentary tag at the base could not be excluded. King (1942) states that he has had a similar experience, but gives no details. Dahl inferred the presence of a communication between the pericardium and left pleural space during artificial pneumothorax treatment for pulmonary tuberculosis in a man aged 20, from a radiograph taken soon after the induction, which revealed a pneumopericardium in addition to a left pneumothorax.

We are prompted to place another example on record not so much on account of the abnormal pericardium, but because it was found together with an unusual developmental anomaly of the lung, an association which may shed some light upon the mechanism of the occurrence of partial deficiency of the pericardium. The case we are about to describe is the first to be directly approached and closely studied during life.

### CASE REPORT

**HISTORY.**—K. M. O'L., female, unmarried, aged 19, attended the Out-patient Department of the London Chest Hospital on Aug. 9, 1940, complaining of pain in the upper part of the left side of the chest

for the past six months. It was described as a dull ache, unrelated to respiration. An unusual degree of breathlessness had been experienced during fairly strenuous exertion, but in the ordinary way her breathing had been unremarkable. She had lost 5 lb. in weight in the preceding three months. There were no other symptoms: no cough and no sputum. General health was good; she felt full of energy; and had been able to do her secretarial work without discomfort.

Past medical history had been completely uneventful and the family record was good.

**ON EXAMINATION.**—Well-built, healthy looking girl. No clubbing of the fingers and no glands palpable. Apex beat in the normal situation. Faint pulsation could be felt in the 2nd left interspace near the sternum. A soft systolic murmur was heard at the apex and a coarser bruit at the pulmonary area. The pulmonary second sound was accentuated and reduplicated. Blood-pressure was 112/72 and equal in the two arms.

Movement of the left upper part of the chest was defective; there was some impaired resonance in the 2nd and 3rd left interspaces close to the sternum; and the breath-sounds on the left side below the clavicle were harsh. No adventitious sounds were heard and there were no physical signs in the chest behind. Other systems were normal.

**Radiology:** Anteroposterior X-ray picture of the chest (Fig. 292) showed a globular shape of heart with a curious thumb-shaped opacity with a smooth outline spreading out from the mediastinum in the neighbourhood of the pulmonary artery. A left lateral view (Fig. 293) showed this opacity to be anterior in position.

A provisional diagnosis of a pulmonary cyst or mediastinal tumour was made and the patient was admitted for further investigation on Aug. 30, 1940.

Temperature was normal except for an occasional ascent to 99° F.; pulse-rate ranged from 80–90 per minute; respiration rate was 20.

**Fluoroscopy:** The mass pulsated, but was distinct from the aorta. It was closely related to the pulmonary artery. There was no enlargement of any of the individual chambers of the heart.

A kymogram confirmed the pulsation of the mass. Electrocardiogram showed normal curves.

Other tests such as blood Wassermann reaction, Friedman test, and blood-count were unhelpful.

When the bombing of London started the patient left hospital before investigations were completed.

She attended the Out-patient Department during the winter of 1940–41, and in November, 1940, she returned to work. There was slight unproductive cough. The pain in the chest sometimes radiated down the inner side of the left arm. Breathlessness was unchanged and she had gained 2 lb. in weight. Physical signs and radiographic appearance were the same.

She continued thus until July, 1941, when the pain increased in severity and penetrated to the back; she experienced "choking sensations", and there was some failure of the general health. There was no alteration, however, in the physical findings, and the X-ray picture showed no increase in the size of the tumour.

As subsequent investigations shed no further light upon the aetiology of the condition, the decision to explore the chest by thoracotomy was reached. A preliminary pneumothorax was induced upon the left side and a radiograph (Fig. 294) showed that the lung

had collapsed and that there was air in the pericardium as well as in the pleural space. The full significance of this observation was not appreciated at the time and the operation was undertaken as planned.

The most obvious part of the pericardial deficiency was above the level of the pulmonary artery in the region of the superior mediastinum, and through this opening the hand was gently passed into the right



FIG. 292.—Anteroposterior X-ray picture of the chest showing an unusual shadow lying on pulmonary artery, and a 'globoid' type of heart outline.



FIG. 293.—Lateral picture of Fig. 292.

**AT OPERATION (Aug. 7, 1941).**—At the Thoracic Unit, Harefield. Anaesthetic by Dr. Parry Brown—evipan, intratracheal gas-oxygen, followed by cyclopropane with controlled respiration.

Left submammary incision. The chest entered along the 4th interspace anteriorly, with division of the 4th costal cartilage.

The first glimpse inside the chest was remarkable for the appearance of a dark red triangular mass moving back and forwards in the mediastinum (Fig. 295). This was the uncovered auricle, which protruded in a tongue-like manner through an opening in the pericardium with each pulsation of the heart-beat. The lung lay collapsed and free from adhesions in the paravertebral gutter; it was normal in shape and in the arrangement and distribution of its lobes.

Lying on the lung was a cyst about the size of a bantam's egg, with a flat pedicle which arose from the left pulmonary artery. The pericardium was absent over a limited area, and when the cyst was lifted upwards it was seen that with its pedicle it accurately filled in the deficiency in the mediastinum. The cyst proper fitted into the superior mediastinum with two small projecting tags or ears lying flush with the upper border. The pedicle and slight downward flap fitted over the auricle and presumably this was the position maintained in life until the induction of the pneumothorax.

The left pulmonary artery was unduly large, with a curve whose convexity faced upwards, forwards, and outwards. Across this vessel at the point where it would normally be covered by pericardial reflection, the attachment of the cyst united in the form of a band about 2 or 3 mm. in thickness. No communication of any part of the cyst attachment with the bronchial tree could be established.



FIG. 294.—A radiograph taken after induction of left-sided pneumothorax. Air is also seen in the pericardium.

side of the pericardial sac beyond which parts of the inner aspect of the right chest wall could be palpated. There was no communication between the pericardium and the right pleural cavity. The lower part of the left side of the pericardium was intact and this prevented the ventricles from being dislodged into the left pleural sac. Actually during manipulation the heart

did become displaced from the pericardium, but it was easily put back without causing any alteration in the rhythm or force of the heart-beat.

The boundary of the pericardial deficiency was defined as follows: Superiorly it formed a curved line in the mediastinum only an inch or so below the level of the pleural dome. Anteriorly the edge descended vertically just behind the line of the



FIG. 295.—Appearance inside the chest, showing the deficiency in the left pericardium and the cyst which has fallen away from it.

phrenic nerve, the course of which it followed until it reached the level of the auriculo-ventricular septum. Here the pericardial boundary passed backwards with a slight downward curve and the edge had a definite rolled appearance. This inferior limit terminated in the lowest part of the cyst pedicle as it was reflected over the pulmonary artery. The posterior margin was ill-defined in its upper part as the consisted of a continuous reflection of the pleura on to Lower down the attachment of the cyst across the enlarged pulmonary artery completed the boundary. The base of the cyst was clamped close to the pulmonary artery, and this caused a bout of coughing. The cyst was removed and the base secured by a few transfixing mattress sutures. The chest was closed without drainage and air was aspirated.

**PROGRESS.**—Convalescence was uneventful, though a trace of fluid developed in the left pleural cavity and in the pericardium. The patient returned home four weeks after the operation. Her later progress has been satisfactory and she has remained free from symptoms. Radiological investigation, however, showed that the original superior mediastinal shadow had persisted, though it is smaller than before the operation. It is felt that the enlarged and curved pulmonary artery is responsible for this appearance, and it is now thought that it was the shadow of this artery rather than that of the cyst which accounted for most of the original radiological abnormality.

**PATHOLOGY** (Dr. Merlin Pryce).—"The cyst measures  $6.5 \times 3.5 \times 2.5$  cm. and is flattened at the cut end while being bulbous towards the other pole (Fig. 296).

"In most parts it is thin-walled, but thicker and botryoid on one side (the lateral or pulmonary face). This part on section is 'polycystic' in character. The cyst contains viscid yellow fluid.

"The chief and subsidiary cysts are lined by ciliated columnar epithelium. In the wall of the main 'cyst' some strands of muscles and masses of cartilage (3 in the cut section) are apparent, also secretory glands.

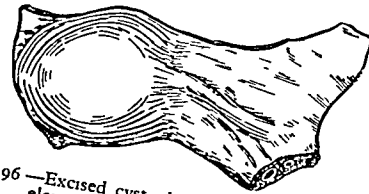


FIG. 296.—Excised cyst, showing divided bronchial elements at the pedicle ( $\times \frac{1}{2}$ ).

"Evidence of chronic inflammation is given by lymphocytic infiltration in the wall of the main cyst: this is much more marked in the region of the smaller cysts, which contain foamy histiocytes. Alveolar spaces in the interstitial tissue contain numerous foamy histiocytes which are sometimes rendered polygonal by crowding. Epithelialization occurs in many of the alveolar spaces—the epithelium varying from cubical to tall columnar ciliated type." The pathology was essentially one of bronchiectasis of the congenital cystic variety, and the cyst acted as part of the left pericardio-pleural membrane. It may be repeated that no communication with any other structure other than the attachment to the left pulmonary artery could be established, this in spite of the presence of bronchial elements in the pedicle. Also the existence of the cyst as a supernumerary or accessory lobe can be excluded in the ordinary sense of the term. The cyst had an association with the pericardial deficiency, and in any discussion as to the aetiology of the condition it is felt that the cyst and the deficiency should be considered together as part of the same process. Embryological study sheds some light on the possible origin of this unusual condition.

### EMBRYOLOGY

The first evidence of the pericardium is the mesodermal thickening at the head end of the minute  $1\frac{1}{4}$ -mm. oval plate and this tissue rapidly canalizes to form the intra-embryonic coelom. Posteriorly the cavity thus formed splits outwards to unite with the extra-embryonic coelom, but anteriorly (and over the future pericardium) the tube remains intact as an inverted U. The posterior free arms of the U open into the extra-embryonic coelom, and the vertical arms represent the pericardio-peritoneal channels, which will become in due course the pleural cavities. The crossbar of the U over the head end is the future pericardium.

In a short space of time the rapid growth of the head end of the embryonic plate carries the pericardium well forward, and as the dorsal aspect moves more quickly than the ventral

surface the head of the embryo becomes bent over and the enlarging pericardial cavity in the 1.5-mm. embryo sweeps ventrally and backwards to lie under the fore-gut at the site of the primitive pharynx. This also implies that the pleural canals connecting the pericardium with the peritoneum no longer run in a straight line fore and aft: the front ends of the tubes curve forwards and ventrally to reach the pericardium.

At the tail end of the heart sac a thickening—the septum transversum—has appeared and vascular elements developing in its substance include the sinus venosus. The vessels that go to form the sinus venosus consist of the umbilical and vitelline veins and more laterally the ducts of Cuvier. The ducts of Cuvier are formed by the junction of the anterior (primitive jugular) and posterior cardinal veins and they play an important part in the closure of the pericardio-pleural channels at a later date (Fig. 297). At

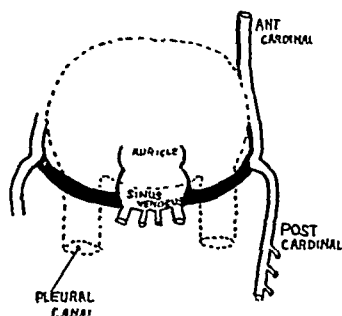


FIG. 297.—Diagram of primitive venous system. Duct of Cuvier in black.

this stage they run on the lateral side of the coelom from the dorsal to the ventral surface of the embryo, but later as the head end of the embryo continues to develop rapidly they take a more oblique course and reach the sinus venosus, moving headwards and ventrally.

An early sign of the respiratory system is a groove in the floor of the fore-gut at the posterior end of the pharynx at the site where the sixth arches will shortly develop. By the time that the embryo has reached a 3-mm. to 4-mm. size the earliest rudiments of the lung appear as buds, and as these expand in the only direction possible to them, namely, laterally, they come into contact with the pericardio-peritoneal channels. The lungs grow into these future pleural sacs and bulge them outwards, but a centrifugal expansion is hindered by certain structures with which the growing lungs come in contact. Dorsally the body wall and caudally the septum transversum act as barriers, so that expansion occurs mainly in the ventral and head directions. This enlargement necessitates the formation of relative folds or constrictions at the front and back ends of the canal between peritoneum and pericardium, structures that may be designated as the pleuro-peritoneal and pleuro-pericardial membranes

respectively. The 5-week embryo is at this stage about 8 mm. long.

The pleuro-pericardial area is important, and it will be noted that the duct of Cuvier is in lateral relation to the canal at this stage (Figs. 298, 299). The duct lies at the head end of the

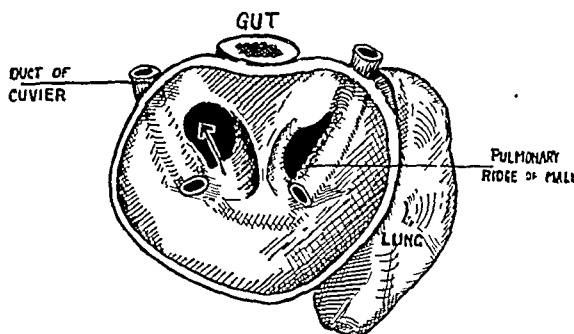


FIG. 298.—View into the embryonic pericardium with the anterior wall cut away. Arrow lies in the right pleuro-pericardial channel (iter venosum).

developing lung bud and is separated from the fore-gut elements by the coelom; it projects into the pericardial sac to form a curved ridge on which a papillary projection (pulmonary ridge of Mall) develops. The opening between the pleura and pericardium has been given the name of the foramen or iter venosum of Lockwood, and the final closure of this foramen will lead to the isolation and separation of the two coelomic elements.

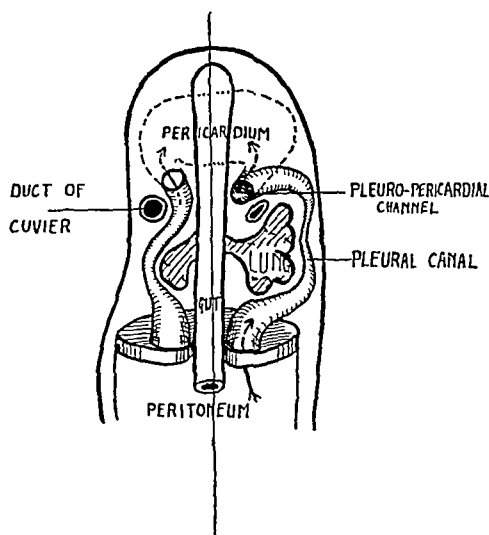


FIG. 299.—Diagram to illustrate relationship of pleural canals to the ducts of Cuvier at different stages of development. On the left the lung bud lies internal and behind the duct; on the right the growing lung has pushed its way lateral to the duct.

The next point to consider is the direction and extent of the expansion of the developing lung. To grow forwards the lung has to pass behind the duct of Cuvier before it can expand adequately; it would be impossible to the future lung apex to force its way mesially to the



duct unless the duct itself showed some abnormality. Consequently the lung tissue forming to the head end of the main bronchus lies lateral to the duct of Cuvier, which becomes driven inwards and ventrally against the pericardio-pleural canal or iter venosum. Finally by a process of elongation and pressure the iter is closed and the pleural sac separated from the pericardium (6-week embryo 12 mm. long).

During the closure of the iter venosum the pulmonary ridges which lie over the ducts of Cuvier lose their original curved course and become strained together obliquely. The ridges meet centrally at the mesodermal stump which represented the dorsal mesocardium and is continuous dorsally with the mediastinum. In this way the pericardium and pleural cavities become separated.

### DISCUSSION

Complete or partial deficiency of the pericardium not uncommonly occurs alone; yet the discovery of associated congenital abnormalities is a feature of many of the recorded cases.

Keith (1912) was puzzled to explain on an anatomical basis the anomaly found in the museum specimen previously described by Curling (*loc. cit.*) until he was dissecting a group of malformed fetuses, two of which displayed the condition. From a study of these specimens he concluded that the anomaly resulted from the lung bud growing within and expanding the communication between the pericardium and

and by McGarry in 1914. Risel observed 3 examples in newly-born infants, all of them showing multiple abnormalities which included in every case a retromediastinal bulge of peritoneum and a diaphragmatic hernia on the left side. The pericardium was partially lacking on the left side in every instance and on the right side also in one of them. He ascribed the primary cause to a persistence of the neurenteric canal. McGarry attributed the abnormalities discovered in his case, which included besides the pericardial deficiency a ventral hernia, left inguinal hernia, double femoral herniæ, and a malposition of the colon with a free mesentery, to a general disturbance of the developing coelom. He assumes that at some stage in the course of its development the coelom may be sensitive to injury, and attributes the almost universal occurrence of partial pericardial deficiency on the left side to the asymmetry of the liver which, in combination with the rotation of the organ during development, places a greater tension on the left pulmonary ridge. These hypotheses are both of a general character and have been based upon limited findings in a small number of cases. They are satisfactory in so far as they explain the particular character of the associated lesions, but are not applicable to the findings of other workers in which pericardial deficiency was found alone or in combination with other defects unrelated to the coelom. Moreover, Risel's argument, in particular, takes no account of the preponderance of left-sided lesions. A right pericardial deficiency has only been recorded on four occasions in man: in three of these (Risel, 1912; Beck, 1931; and Chiodin, 1932) the abnormality was also accompanied by a left-sided deficiency, while in Egbert and Little's case (1935), which is unique, the left half of the pericardium was intact, but the right half was almost entirely missing, with the heart and right lung occupying the same serous cavity.

It is clear, therefore, that a working hypothesis must not only explain how the pericardium comes to be lacking, but must also show why its occurrence on the left side is so preponderant. Keith supplies a partial answer to the first point and his description of the foramen as a patency of the iter venosum is probably correct. It is difficult, however, to agree with him in placing the main responsibility upon the developing lung bud, and in order to envisage both how the iter venosum remains patent and why it occurs usually on the left side it is necessary to turn to the "vascular atrophy theory" put forward by Perna (1909) and Plaut (1913). These authors maintain that if the normal atrophy of the left common cardinal vein was premature then an incomplete development of the associated pleuro-pericardial membrane might result from a deficient blood-supply. When the structures which develop from the duct of Cuvier are considered it will be seen that on the right side its persistence as the wide-bore superior vena cava will ensure that the iter

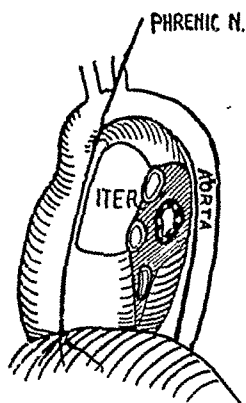


FIG. 300.—Diagram to illustrate the position of the iter venosum of Lockwood. Heart viewed from the left. The phrenic nerve is the anterior boundary. The pulmonary artery and superior vein lie posterior. (After Keith.)

pleura, for this communication lies immediately ventral to the point at which the lung bud appears (Fig. 300). He pictured the condition as a dilatation of the pleuro-pericardial foramen, a foramen which in the ordinary way closes completely, and in a later work (Keith, 1933) refers to it as a "patency of the iter venosum of Lockwood". Keith's contention as to the mechanism of the production of partial pericardial deficiency was challenged by Risel in 1912

venosum on that side will close and only exceptionally will it permit a patency of the pleuro-pericardial canal. On the left side, however, atrophy of the duct is the normal procedure. Part of the superior intercostal vein is its first definite representative: it then dwindles to a remnant which lies in the vestigial fold of Marshall, stretching between the pulmonary artery and the superior pulmonary vein, to end as the oblique vein of Marshall, a variable structure

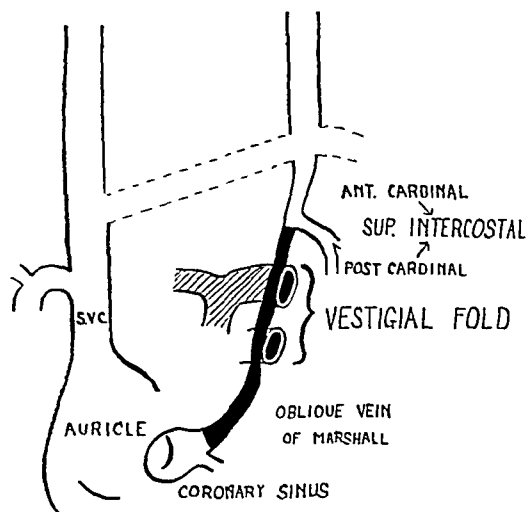


FIG. 301.—Diagram to depict the evolution in the adult of the venous elements. Left duct of Cuvier is represented in black.

which lies over the posterior aspect of the left auricle and enters the coronary sinus (Fig. 301). As Keith has pointed out, a failure of the iter venosum to close will result in the adult in a communication between the pericardial and pleural cavities ventral (anterior) to the remnant of the duct of Cuvier and will be limited by the extent to which the pericardium has developed at the time at which closure fails to take place. Thus, the size of the communication between pericardium and pleura will be determined by the stage of development reached when the left duct of Cuvier atrophies. An important finding is that of Niccoli (1929), who noted an associated absence of the coronary sinus and therefore gives anatomical support to the above hypothesis.

In view of the intimate relationship which exists between the lung bud and the duct of Cuvier, it would be possible for an early atrophy of the duct to lead to a disturbance of the development of the lung bud on the same side. In some of the published accounts this was found to be the case. For example, Watt (1931) found that in his case the left lung had four lobes, while Chiodin (1932) found a right lung divided by fissures into "pseudo lobes". Again, Risel (1912) described pulmonary abnormalities in two of his cases. In the course of its development the duct of Cuvier comes to lie at the head end of the growing lung bud, which in order to grow

forwards and expand has to pass behind the duct. It would be difficult for the future lung apex to force its way through to the mesial side of the duct unless the duct itself were abnormal. Premature atrophy might enable this to occur. If the portion of lung bud so isolated continued to develop normally the result would be an extra lobe and one that would be ideally placed to pass through the opening of the pleuropericardial canal and come to lie within the pericardial cavity as has been described. If, on the other hand, normal development of the migratory part of the lung ceased at this point it would be well in keeping with current theories regarding the aetiology of lung cysts (Sellors, 1937) to imagine that the outcome would be a solitary cyst composed of bronchial elements and of approximately the same size as the opening into the pericardium—in other words, a cyst having precisely the characteristics and disposition of the one which was found in our patient.

A discussion of this condition would be incomplete without reference to the function of the pericardium and the significance of its absence. There have been several series of experiments conducted upon animals which have a bearing upon this point. Kuno (1915) found that opening the pericardium in dogs allowed of a larger output of the left ventricle on account of increased diastolic excursion. Parlavacchio (1909) concluded that the chief consequence of the operation was hypertrophy of the left ventricle. Carleton (1929) found that removal of the pericardium caused no alteration in heart rate or blood-pressure in cats. Radiographs were taken, and these showed that the cardiac shadow was permanently enlarged owing to dilatation and not to hypertrophy. He concluded that a restraining action is exerted by the pericardium, a restraint which is relative and not absolute, and thus disagreed with Barnard (1898), who maintained that the pericardium is an inextensible membrane.

A study of the literature indicates that in the human subject absence of the pericardium is without significance. Barsoum (1935) alone attributed the cardiac dilatation and insufficiency from which his patient died to an absence of the pericardium, which was almost total, while in Boxall's case (1887) a partial deficiency was responsible for a unique complication of the puerperium in a 28-year-old woman in whom three days after delivery the heart herniated through the foramen and thus caused death. Grant (1926) has investigated the literature with a view to determining the effect of pericardial deficiency upon heart size, and concluded that although the pericardium might support a dilating heart in such abnormal circumstances as asphyxia by drowning, it plays no part in preventing overdistension, and its absence is not a factor in causing cardiac enlargement.

A noticeable feature of many of the cases reported in the literature is the accidental discovery

of this abnormality at autopsy on men of moderately advanced age who have led strenuous lives and who have died of a totally unrelated disease.

It must be emphasized, however, that the presence of such an abnormality does increase the dangers attaching to certain respiratory diseases. Air or fluid in the pleural cavity on the same side as the pericardial deficiency might gain access to the pericardial cavity and if occurring in a tuberculous person would hamper treatment by pneumothorax as in Dahl's case already cited. It is, however, in infection that that the danger is greatest. Southworth and Stevenson (1938) found in the cases cited by them that pneumonia had caused death in 19 per cent, while in 27 per cent there was evidence of fresh pleuropericarditis. Should empyema occur, the risk to life is further increased.

### SUMMARY

A case of partial deficiency of the pericardium associated with a solitary bronchogenic cyst, both on the left side, occurring in a girl of 19, is described. This is the eightieth case of pericardial deficiency to be placed on record; the third to be recognized during life; and the only one carefully studied at operation.

The symptoms of which this patient complained can be attributed to the lung cyst, which was removed. An uneventful recovery followed, and good health has been enjoyed since operation.

The literature relating to pericardial deficiency is shortly reviewed.

An account of the development of the pericardium and lung is given, and a possible mechanism for the occurrence of absence of pericardium is discussed in the light of previous theories which have been propounded. It is contended that the association of a lung cyst with a partial left-sided deficiency of pericardium lends weight to the view that the latter defect is the result of abnormal development with premature atrophy of the left duct of Cuvier.

The name given to this condition by Keith, *patency of the iter venosum*, is believed to be accurate and it possesses the added advantage of according well with the nomenclature in current use for other developmental abnormalities of the cardiovascular system.

### APPENDIX

R. L. Moore in 1925 computed the total number of recorded cases of pericardial deficiency at 64. The 13 references marked with an asterisk

contain the additional 15 case reports that have been found in the literature since the publication of Moore's paper.

### REFERENCES

- BAILLIE, M. (1793), *Trans. Soc. Improvement Med. Chir. Knowledge*, 1, 91.
- BALY, W. (1850-52), *Trans. path. Soc. Lond.*, 3, 60.
- BARNARD, H. L. (1898), *J. Physiol.*, 22, 43.
- \*BARSOUM, H. (1935), *Brit. med. J.*, 2, 666.
- \*BECK, C. S. (1931), *Arch. Surg.*, 22, 282.
- \*BEYER, R. (1938), *Z. Kreisl.-Forsch.*, 30, 411.
- BOXALL, R. (1887), *Trans. obst. Soc. Lond.*, 28, 209.
- BRISTOWE, J. S. (1854-55), *Trans. path. Soc. Lond.*, 6, 109.
- CARLETON, H. M. (1929), *Proc. R. Soc. B.*, 105, 230.
- \*CHIODIN, L. A. (1932), *Bol. Soc. argent. Biol.*, 8, 361.
- CURLING, T. B. (1838-39), *Med.-Chir. Trans.*, 22, 222.
- \*DAHL, E. (1937), *Med. Rev., Bergen*, 54, 312.
- EBSTEIN, E. (1910), *Munch. med. Wschr.*, 57, 522.
- \*EGBERT, D. S., and LITTLE, S. (1935), *Yale J. Biol. and Med.*, 8, 19.
- \*GRANT, R. T. (1926), *Heart*, 13, 371.
- \*KADIN, M. (1939), *J. Mich. med. Soc.*, 38, 503. (3 cases.)
- KEITH, A. (1906-7), *J. Anat.*, 41, 6.
- (1933), *Human Embryology and Morphology*, 5th ed., 346. London: Arnold.
- KING, E. S. J. (1941), *Surgery of the Heart*, 524. London: Arnold.
- KUNO, Y. (1915), *J. Physiol.*, 50, 1.
- \*LADD, W. E. (1936), *New Engl. J. Med.*, 214, 183.
- LITTRE, M. (1712), *Histoire de l'Académie royale des Sciences*, Paris, 1731, 26 (quoted by CURLING, T. B., q.v.).
- MCGARRY, R. A. (1914), *Anat. Rec.*, 8, 43.
- MOORE, R. L. (1925), *Arch. Surg.*, 11, 765.
- \*NICCOLI, L. (1929), *Bol. Soc. med.-chir., Pavia*, 43, 499.
- \*OSGOOD, R., and SPECTOR, B. (1941), *Amer. J. Dis. Child.*, 61, 1028.
- OTTO, A. W. (1831), *A Compendium of Human and Comparative Pathological Anatomy*. (Trans. J. F. South.) Section 19, 162, 253. London: B. Fellowes.
- PARLAVECCHIO, G. (1909), *Deuts. Z. Chir.*, 98, 126.
- PEACOCK, T. B. (1866), *On Malformations of the Human Heart*, 2nd ed., 12. London.
- PERNA, G. (1909-10), *Anat. Anz.*, 35, 322.
- PLAUT, M. (1913), *Frankfurt. Z. Path.*, 12, 141.
- POWELL, R. D. (1869), *Trans. path. Soc. Lond.*, 20, 99.
- SELLORS, T. H. (1938-39), *Tubercle*, 20, 49 and 114.
- \*SOUTHWORTH, H., and STEVENSON, C. S. (1938), *Arch. intern. med.*, 61, 223.
- VIEUSSENS, R. (1715), *Traité nouveau de la Structure et des Causes de Mouvement naturel du Cœur* 1ry ed., 3. Toulouse: Jean Guillemette.
- \*WATT, J. C. (1931), *Arch. Surg.*, 23, 996.

## ACUTE APPENDICITIS AND THE APPENDIX MASS

BY A. G. MCPHERSON AND J. B. KINMONTH

THIS paper analyses 730 cases of acute appendicitis treated in St. Thomas's Hospital in the period 1937-1942 inclusive. In general, we have considered the cases under the same grouping as two similar analyses of St. Thomas's Hospital cases made in 1903 and 1932 (Wallace and Sargent, 1904; Sworn and Fitzgibbon, 1932). Interesting comparison over this 40-year period is thus possible.

This series includes only definite cases of acute appendicitis, all doubtful cases have been excluded. In cases submitted to early operation clear naked-eye evidence of acute inflammation was the criterion taken, microscopical evidence alone of inflammation was not accepted. In the cases of masses where immediate operation was withheld, only those cases in which there seemed to be no reasonable doubt as to the diagnosis have been accepted. The majority of the cases in this group later submitted to interval operation showed clear evidence of previous appendicitis.

**Explanation of Grouping.**—The cases have been divided into three groups: (1) Simple appendicitis; (2) Appendicitis with diffuse peritonitis; and (3) Appendicitis with mass; and it is necessary to define what we mean by these terms. By simple appendicitis we mean that disease is limited to the appendix or only a localized peritonitis has occurred. Appendicitis with diffuse peritonitis is a diagnosis arrived at in part from operative findings, but since it is frequently impossible to tell the precise extent of peritonitis at operation without a dangerously extensive exploration, pre-operative physical signs such as rapid pulse, diffuse tenderness, and extensive rigidity have also been taken into account.

We mean by appendicitis with mass, a clinical condition where in addition to the signs and symptoms of appendicitis, a mass in the right iliac fossa has been palpable without anaesthesia. It has appeared to us from a study of the literature, that in those clinics where routine immediate operation is practised, no particular point is made of looking for a mass, whereas at this hospital where it is the practice to treat appendix masses expectantly, the surgeon takes special pains to ascertain, in cases where a mass might be expected, if one is in fact present. Since this may require prolonged gentle palpation, particularly where rigidity is present, it seems that many cases with mass will not be discovered unless the surgeon has this in mind.

There is little reference to the term 'appendix mass' in the literature and frequently it is confused with the term 'appendix abscess'. It is true that a certain number of masses will contain some pus or that they may on occasion become frank abscesses, but nevertheless the terms are not synonymous. We mean by 'mass' a palpable lump surrounding an inflamed appendix, and

this certainly in the early stages, as we know from cases which have been operated on at this stage, consists of an inflammatory mass of oedematous adherent tissues, the appendix itself being surrounded and walled off by swollen and oedematous omentum, mesentery, and coils of bowel.

#### Management of Acute Appendicitis.

There is no general agreement as to the management of acute appendicitis, although it is agreed that early cases should be operated on. For the rest there are two schools, the immediate operation school and the expectant treatment school. Among those who advocate expectant treatment the indications are not always the same and therefore it is necessary to show which type of case has been treated conservatively in this series. In this series early cases have been treated by immediate operation. In later cases, over 48 hours, the patient's general condition has been carefully assessed and a mass looked for. The presence of a mass indicates an attempt on the part of the peritoneum to localize the infection, and if this attempt appears to be succeeding, interference has been regarded as meddling, and as long as there has been no evidence suggesting that localization has failed the case has been treated conservatively. It will be seen that operation has only been withheld where there was evidence of satisfactory localization, and we would emphasize that the clinical findings, rather than the length of history, decide the management. If there has been evidence suggesting a spread of infection in the peritoneum, or if the patient was admitted with frank diffuse peritonitis, operation was advised. This conservative treatment is not to be confused with the Ochsner treatment applied to cases with general peritonitis.

**Treatment of 'Mass Cases'.**—Cases with a mass and treated expectantly are put to bed in low Fowler's position, no sedatives, enemata, or aperients are allowed, fluids (in small amounts only) are given by mouth, and the half-hourly pulse-rate is charted. Indications for abandoning conservative treatment are as follows: rising pulse or persistently elevated pulse-rate (more than 100); increasing signs or symptoms suggesting a spread of infection; at a later stage abscess formation; and very occasionally a failure to resolve.

Conservative treatment is not advised for children, the aged, or in pregnancy, unless a very firm and localized mass is present on admission, and this is uncommon in these types.

Interval appendicectomy, three months after resolution of the mass, is recommended for those cases which have settled down satisfactorily under conservative treatment. Exception is made only for patients where age or general condition is such as to contra-indicate abdominal operation.

**Treatment of Peritonitis.**—Cases admitted with diffuse peritonitis are treated by early appendicectomy. If there is any delay its object is to improve the patient's condition by general means, such as intravenous saline or nasogastric suction, preparatory to operation.

### GENERAL CONSIDERATIONS

**Age.**—In the present series ages range from 2½ to 82 years. *Fig. 302*, in which the age

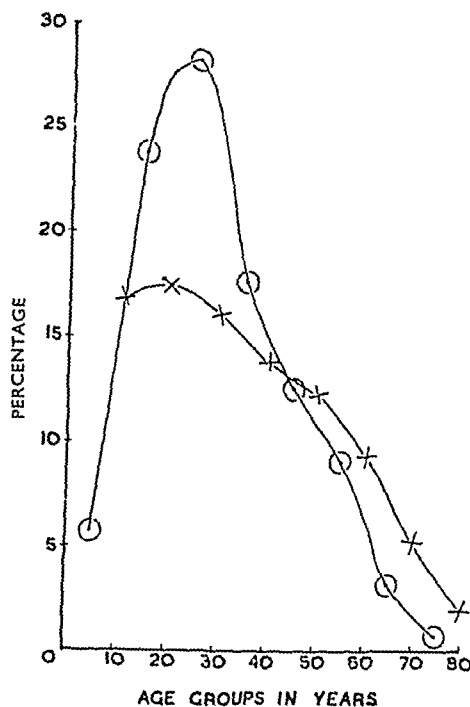


FIG 302.—Age incidence of all forms of appendicitis compared with that of normal population. o—o, Appendicitis, x—x, Normal population.

incidence for all cases is compared with that of the normal population, shows a preponderance of cases in the second and third decades of life.

steadily increasing tendency to mass formation with age. *Fig. 304* shows a much higher mortality-rate in older people.

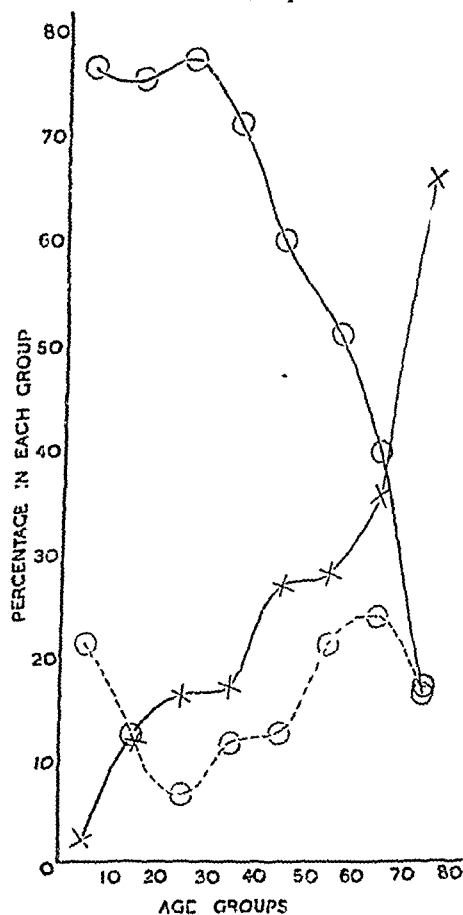


FIG 303.—Relative incidence of different forms of appendicitis. o—o, Simple appendicitis, o---o, Appendicitis with peritonitis, x—x, Appendix mass

**Sex.**—There were 446 males and 284 females. It is important to note the preponderance of one or other sex if comparison is to be made with

Table I.—INCIDENCE RELATED TO LENGTH OF HISTORY

	DAY OF ILLNESS										
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10-14th	Over 14th
All cases	356	182	76	41	17	11	17	9	5	28	8
Simple acute appendix	336	143	17	7*	0	1	5*	1	0	0	1
Appendix with peritonitis	17	24	30	7	7	0	0	0	0	2	0
Appendix mass	3	5	29	17	10	10	9	8	5	26	7

\* Two cases without mass or peritonitis, which were not operated upon, are included.

This confirms the findings of other authors. Most cases of peritonitis and masses also occurred in these decades. *Fig. 303* in which simple appendicitis, peritonitis, and mass cases are compared on a basis of incidence of each per 100 cases of all types, shows: (1) a higher incidence of peritonitis at the extremes of life, and (2) a

other series of appendicitis cases because the case mortality for the two sexes differs. Figures collected by Young and Russell (1939), show that the mortality-rate for females is about two-thirds that for males. In the present series the mortality-rate is 3.1 per cent in males and 2.5 per cent in females.

**Length of History (Table I).**—In 28 per cent of patients there was a history longer than 2 days. The average length of history for the whole series was 2.4 days. For all cases without a palpable mass it was only 1.42 days and for the mass cases 7.2 days. Table I shows the incidence on each day for the groups separately and combined. Table VIII shows that the mortality rises with increasing length of history.

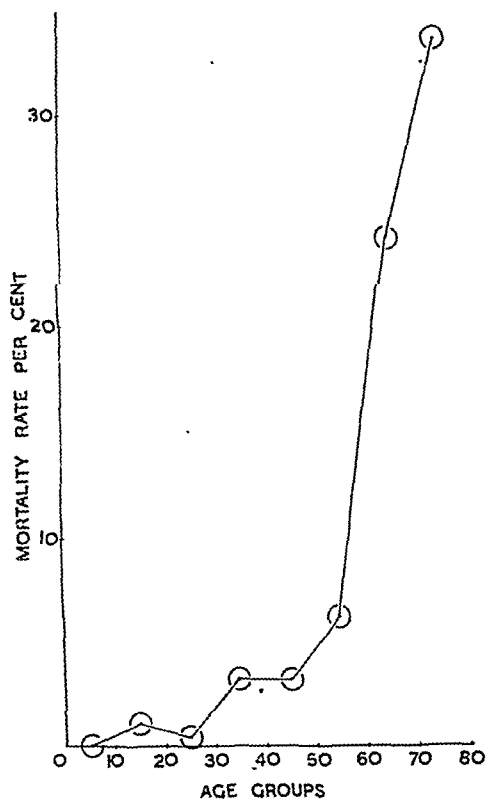


FIG. 304.—Mortality-rate in age groups (all cases).

**Details of the Three Main Groups in this Series.**—There were 511 cases of simple acute appendicitis, 90 with diffuse peritonitis, and 129 with a mass.

Tables II–IV analyse the groups separately, showing mortality, complications, and time in hospital.

Table II.—SIMPLE ACUTE APPENDICITIS  
IMMEDIATE OPERATION

DAY OF ILLNESS	NO. OF CASES	MORTALITY		COMPLICATIONS
		Cases	Per cent	
1st	336	2	0.59	26
2nd	143	3	2.15	17
3rd	17	1	5.88	2
4th	6	—	—	1
5th and over	7	—	—	1
Totals	509	6	1.17	47 (9.13 per cent)

There were 2 cases of mild acute appendicitis described on admission as 'settling' which were not operated upon. They are excluded from the above table.

Average time in hospital, 12.6 days.

Table III.—ACUTE APPENDICITIS WITH DIFFUSE  
PERITONITIS. IMMEDIATE OPERATION

DAY OF ILLNESS	NO. OF CASES	MORTALITY		COMPLICATIONS
		Cases	Per cent	
1st	17	2	11.76	4
2nd	24	5	20.83	5
3rd	30	4	13.33	7
4th	7	1	14.29	1
5th and over	12	2	16.67	3
Totals	90	14 (15.6 per cent)		20 (22.2 per cent)

Average time in hospital, 30.3 days.

Simple acute appendicitis is much the largest group. Masses occur rather more commonly than diffuse peritonitis.

The mortality-rate in simple appendicitis is 1.17 per cent, in contrast to 15.6 per cent in cases with diffuse peritonitis. Only 1 case in which a mass had been felt before operation died, giving a figure of 0.8 per cent. No deaths followed interval appendicectomy.

Conservative treatment was abandoned in 31 cases and the reasons are listed in Table V. One case of appendix abscess, which was drained on the fourteenth day, died of reactionary hæmorrhage. Two cases appear to have been operated

Table IV.—ACUTE APPENDICITIS WITH PALPABLE MASS

SETTLED WITH EXPECTANT TREATMENT			REQUIRING EARLY OPERATION			
Day of Illness	Interval Operation	No Operation	Appendicectomy	Drainage only	Interval Operation	No Interval Operation
1st	2	0	1	1	0	1
2nd	13	3	5	0	0	0
3rd	11	8	6	1	1	0
4th	6	6	1	0	0	0
5th and over	30	19	11	5	3	1
Totals	62	36	24	7	4	2

Total all cases, 129 with 1 death (0.8 per cent); this followed simple drainage of a fifth-day case. Average time in hospital, 32.9 days. Complication rate, 8.2 per cent.

upon without clear indication: in 1 case the clinical mass disappeared rapidly and operation was performed on the eleventh day; appendicectomy proved very difficult owing to firm adhesions and the cæcum was torn during the manipulations. In the second case, which was operated upon on admission, without definite indication, a very firm mass was found and cœliotomy only was performed.

Table V.—INDICATIONS FOR OPERATION IN CASES WITH PALPABLE MASS ON ADMISSION

	Cases
Diffuse peritonitis, immediate operation	6
Deterioration during observation period	5
Abscess present	1
Abscess developed during observation period	7
Recurrent attack during 'interval'	4
Age (child)	1
Uncertainty as to nature of mass	5
None noted	2
Total	31

**Complications.**—The complication rate is highest, as would be expected, in the diffuse peritonitis group. It is to be noted that it is lowest in the palpable mass group, including those which came to operation. We have excluded from *Tables II-IV* cases where healing by first intention was not obtained through suppuration in the wound, but without other complications. These cases appear to be omitted by other authors and are of frequent occurrence.

*Table VI* shows details of the complications occurring in the various groups. Many of these are chest complications, e.g., atelectasis and

Another is that a number of patients default and do not return for interval appendicectomy.

The percentage who did not have interval operation in this series is unquestionably a large one, but we feel that the number is larger than would occur in normal times, since the majority of these cases have occurred during the war. Under the present circumstances it is more difficult to keep in touch with patients and more difficult to persuade them to return to hospital when they have felt fit and perhaps been doing remunerative or important war work.

In spite of these criticisms we feel that the mortality is the important deciding factor, and it is significant that 1 only of the mass cases died, and this followed operation for appendix abscess. The mortality-rate for masses is the lowest of the three groups (including simple acute appendicitis), and this despite the longer average history—a factor usually agreed to raise the mortality. Would it be still lower if immediate operation was the rule? A categorical statistical answer is impossible. One cannot get a series of masses treated by immediate operation for comparison, because surgeons practising such a method do not recognize or classify such cases in a separate category.

Nevertheless, it seems unlikely that immediate operation on these cases would produce a lower mortality-rate than for simple acute appendicitis. Further, on general surgical grounds it does not appear to us to be a sound policy to interfere with an infective process in the peritoneum where there is evidence that localization by natural processes has already been achieved.

Table VI.—NON-FATAL COMPLICATIONS OF THE THREE MAIN GROUPS

	SIMPLE APPENDICITIS	APPENDICITIS WITH PERITONITIS	APPENDICITIS WITH MASS	ALL CASES
Hæmatoma	3	—	—	3
Residual abscess	2	3	1	6
Pelvic Abscess	7	7	3	17
Fæcal fistula	—	1	—	1
Paralytic ileus	—	3	—	3
Acute obstruction	1	1	—	2
Burst abdomen	—	—	1	1
Bronchitis	7	1	—	8
Atelectasis	18	—	3	21
Pneumonia	4	2	—	6
Pulmonary infarct	3	1	2	6
Femoral thrombosis	1	1	—	2
Delirium tremens	1	—	—	1
Total cases	511	90	129	730
Total complications	47 (9.2 per cent)	20 (22.2 per cent)	10 (7.8 per cent)	77 (10.5 per cent)

bronchitis, and are not directly related to the appendicular lesion.

**Morbidity, and the Mortality-rate of Mass Cases.**—The time spent in hospital averaged 12.6 days in simple appendicitis, 30.3 days in general peritonitis, and 32.9 days in the mass cases returning for interval appendicectomy.

One criticism of the practice of delaying operation in selected cases is that a longer stay in hospital is required.

**Observations on the Fall in Mortality-rate in 40 Years.**—It is interesting to follow the fall in mortality of acute appendicitis in the last 40 years as shown in *Table VII*, and to postulate causes for this.

Table VII.—COMPARISON WITH PREVIOUS ST. THOMAS'S HOSPITAL FIGURES

Series A. 1894-1903—433 cases with 182 deaths (42 per cent)  
 Series B. 1920-1929—1755 cases with 86 deaths (4.9 per cent)  
 Series C. 1937-1942—730 cases with 21 deaths (2.9 per cent)

## I. Acute appendicitis without peritonitis :—

A.	13 cases	0 deaths	
B.	1340 cases	23 deaths	(1.7 per cent)
C.	509 cases	6 deaths	(1.17 per cent) (operated cases only)

## II. Acute appendicitis with diffuse peritonitis :—

A.	166 cases	143 deaths	(86.0 per cent)
B.	226 cases	48 deaths	(21.1 per cent)
C.	90 cases	14 deaths	(15.6 per cent)

## III. Cases with clinically palpable mass :—

A.	254 cases	39 deaths	(15.3 per cent)
B.	189 cases	15 deaths	(7.9 per cent)
C.	129 cases	1 death	(0.8 per cent)

In the earliest series (Wallace and Sargent, 1904) appendicitis was treated in medical wards and the surgeon was called in at a later stage.

Of the patients in Sworn and Fitzgibbon's series (1932) 48 per cent had a history longer than 48 hours, compared with 28 per cent in this series.

Table VIII shows the increasing mortality of cases after the first day. The time factor is, in our opinion, one of the greatest, if not the greatest factor in the lowered mortality-rate.

Table VIII.—MORTALITY RATE IN RELATION TO LENGTH OF HISTORY

DURATION OF SYMPTOMS ON ADMISSION	DAYS								
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
No. of cases	356	171	75	29	17	11	15	9	5
No. of deaths	4	8	5	1	2	0	1	0	0
Mortality rate per cent	1.1	4.7	6.7	3.4	11.8	—	6.7	—	—

A point which may be of importance, and one that has been frequently emphasized in the past, is the danger of aperients. We have no accurate data as to the number of cases which had been given purgatives before being sent to hospital, but it is our impression that the number is small and that the general public and the practitioner are both more fully aware nowadays of the danger of giving purgatives for undiagnosed abdominal pain.

Intravenous drip saline and continuous nasogastric suction have been fully employed in the present series in cases with peritonitis, and we consider these of great value.

Although some of our late cases have been given sulphonamides, these drugs have only rarely been given intraperitoneally and we are doubtful if they have had any influence on the mortality figures in this series.

Changes in anæsthetic technique and the more frequent use of local anæsthesia in the worse cases may also have helped to lower the mortality.

The low mortality of cases with a mass is remarkable, and the drop in mortality in this group as compared with the figure of Sworn and Fitzgibbon (1932) is very much larger than the drop in the earlier groups. All the above-mentioned factors influence this, but, perhaps the most important factors are the improvement in the selection and the technique of management of cases for conservative treatment. A greater proportion of the mass cases in Sworn and Fitzgibbon's series had early operation (38 per cent)

VOL. XXXII—NO. 127

compared with 24 per cent in the present series, many more of these being operated on at once. It is amongst these early operation cases that the deaths occur.

**Analysis of Deaths.**—Table IX shows the causes of death in the 21 fatal cases. Diffuse peritonitis, as would be expected, accounts for the largest number. Other causes are individually few.

Table IX.—CAUSES OF DEATH

Causes of Death	No. of Cases
Diffuse peritonitis	12
Subphrenic abscess—general peritonitis	1
Bronchopneumonia	1
Hæmorrhage and shock	2
Secondary hæmorrhage	1
Pulmonary embolus	1
Paralytic ileus—without peritonitis	1
Gas gangrene of wound	1
Hypertensive cardiac failure	1

Two cases died of shock and hæmorrhage and these deaths are theoretically avoidable.

Of the 8 cases where a previously unperforated appendix was ruptured on removal, 2 died, one of a spreading gas infection of the abdominal wall and the other of a pulmonary embolus. Both of these cases had short histories of under 24 hours and showed no diffuse peritonitis at operation and belong to a type of case normally carrying a good prognosis.

No case of simple appendicitis or appendicitis with mass died of diffuse peritonitis, though this was the cause of death in practically all those of the peritonitis group.

The average age of the fatal cases was 46.3 years, much higher than the average of the whole group. Eight patients were aged 60 or over. This conclusively demonstrates that the prognosis is much worse in the aged.

**Comparison with other Series in the Literature.**—It is not possible to make any strict comparison between the figures in different series, and it may indeed be misleading. There are far too many variable factors involved.

The criteria of diagnosis are often different—in some series milder cases are included on microscopical evidence of acute inflammation only, or 'subacute' or chronic cases are accepted.

Different sex composition of series also invalidates comparison.

It is well known that collective figures for an institution should not be compared with those for individual surgeons without allowance being made. Other things being equal, better figures are naturally to be expected from the individual.



A series in which a high proportion of peritonitis cases occurs cannot be compared with one with a smaller proportion of these cases.

Comparison of the various types of acute appendicitis is even more difficult as the methods of grouping adopted by different authors varies enormously. This is especially so with 'mass' cases, as such a subdivision is very rarely made. Many authors subdivide their cases into numerous types: e.g., peritonitis—'local', 'flank', 'diffuse', 'spreading', 'general', and such terms occur frequently in the literature. It is difficult to understand how the separate entity of these groups can be clearly established.

Comparison of subgroups also means comparison of smaller numbers of cases, so that errors of chance play a larger part.

Therefore, we have not attempted any comparison of subgroups of appendicitis, but include in Table X some figures from the literature to which fewest of the above invalidating objections apply.

Table X.—MORTALITY RATE FOR ACUTE APPENDICITIS (ALL TYPES) IN OTHER SERIES IN THE LITERATURE

AUTHOR	DATE	NO. OF CASES	MORTALITY RATE Per cent	REMARKS
Nuttall	1935	617	2.6	Immediate operation
Holman	1938	1,200	4.8	Immediate operation
Stafford and Sprong	1940	1,317	3.6	Immediate operation
Barrow and Ochsner	1940	1,039	5.3	Some peritonitis cases treated conservatively
Miller et al.	1940	656	5.4	Expectant treatment for masses. All patients children
Mason et al.	1941	1,163	1.5	Expectant treatment for masses. Very few peritonitis cases.
Present series	1943	730	2.9	Expectant treatment for masses

It is interesting to note the figures of Miller and his co-authors (1940). Their patients were all children, the same grouping is applied as we have used in our series, and the same regimen of expectant treatment adopted for masses—an unusual practise where children are concerned, but one which their low mortality figure of 3.1 per cent for such cases appears to justify.

In reviewing the recent literature relating to the treatment of acute appendicitis we have noticed that nearly all authors, however keen protagonists they may be of the immediate operation policy, make some reservations. There seems to be a feeling that there are cases better treated conservatively and very often it is expressed by a remark about late cases with a palpable mass (felt clinically), or it may be in a word of advice about dealing with an appendix mass found at laparotomy. The 'mass' does not find much place in their statistics, however, and we feel that it is more common than is generally realized and that searching for it a little more carefully and treating it expectantly well repays the surgeon.

#### SUMMARY

A total of 730 cases of acute appendicitis treated at St. Thomas's Hospital have been

analysed. Particular attention has been drawn to acute appendicitis with mass formation.

Conservative management of appendix masses is recommended and rules for selection of cases for expectant treatment are given. The figures quoted justify this conclusion.

The effects of age, sex, and length of history on mortality are discussed.

The mortality-rate for the whole series is 2.9 per cent, for simple acute appendicitis 1.7 per cent, for peritonitis cases 15.5 per cent, and for masses 0.8 per cent.

Complications and length of stay in hospital are discussed.

A comparison is made with previous series treated at St. Thomas's Hospital during the last 40 years.

Analysis is made of the individual causes of death.

The literature has been reviewed and the figures of a few of the more comparable recent series have been tabulated.

Our thanks are due to the Surgeons of St. Thomas's Hospital for permission to publish the results of these investigations.

#### BIBLIOGRAPHY

- BARROW, W., and OCHSNER, A. (1940), *J. Amer. med. Ass.*, 115, 1246.  
 HILL, A. BRADFORD (1942), *Principles of Medical Statistics*. Lancet Ltd.  
 HOLMAN, C. C. (1938), *Lancet*, 2, 126.  
 LOEWENTHAL, L. J., and WILSON, W. A. (1939), *Brit. med. J.*, 2, 110.  
 MASON, M. L., et al. (1941), *Qnty. Bull., Nthwest. Univ.*, 1, 15.  
 MILLER, E. M., FELL, E. H., BROCK, G., and TODD, M. C. (1940), *J. Amer. med. Ass.*, 115, 1239.  
 NUTTALL, H. W. C. (1934), *Brit. J. Surg.*, 21, 411.  
 — (1935), *Brit. med. J.*, 2, 1045.  
 STAFFORD, E. S., and SPRONG, D. H. (1940), *J. Amer. med. Ass.*, 115, 1242.  
 SWORN, B. R., and FITZGIBBON, G. M. (1932), *Brit. J. Surg.*, 19, 410.  
 TURNER, G. G. (1938), *Brit. med. J.*, 2, 691.  
 WALLACE and SARGENT (1904), *St. Thomas's Hosp. Rep.*  
 WILKIE, D. P. D. (1931), *Brit. med. J.*, 1, 253.  
 YOUNG, M., and RUSSELL, W. T. (1939), *M. R. C. Special Rep. No. 233*. H.M. Stationery Office.

## STENOSIS OF THE SMALL INTESTINE FROM THE CICATRIZATION OF ISOLATED INFLAMMATORY LESIONS

By MILROY PAUL

PROFESSOR OF SURGERY, UNIVERSITY OF CEYLON

STENOSIS of the small intestine would be symptomless until the lumen of the bowel were so narrowed as to interfere with the passage of the intestinal contents. As the contents of the small intestine are fluid considerable narrowing would occur before symptoms were caused, and it has been justly estimated that the lumen of the bowel could be narrowed to the diameter of a lead pencil without causing symptoms. An inflammatory lesion could not produce stenosis until some considerable time had elapsed from its inception.

Whether an inflammatory lesion of the small intestine could produce symptoms apart from those of stenosis is debatable. The exudate from an isolated inflammatory lesion would be negligible, and an isolated ulcer in the small intestine would probably be symptomless. Some writers have, however, attempted to describe clinical syndromes for ulcers of the small intestine on the same plan as the clinical syndrome for gastric and duodenal ulcers. Smith (1935) states that although no typical group of symptoms has been encountered, an abstract of the literature makes possible a collection of symptoms found in proven cases of jejunal ulcers. Pain in the epigastrium or left upper abdomen made worse by eating; pain which is non-radiating, appearing at no appointed time as regards meals and of a dull boring character; pain unrelieved by the taking of food or alkaline powders; pain with intervals of freedom of two or three months; occasional nausea and an indefinite area of tenderness in the left upper abdomen make up this syndrome. It is unlikely that a laparotomy would be performed for such a syndrome and the validity of this syndrome remains undecided at present. However this may be, it is certain that most cases are symptomless until there is mechanical obstruction to the flow of the intestinal contents. At this stage the patient would experience recurrent attacks of circum-umbilical abdominal pain, and observation would demonstrate visible peristalsis of the ladder pattern associated with these bouts of pain. Such a clinical picture is unmistakable, and calls insistently for relief by a surgical operation. Vomiting might or might not be present, but would be more marked the higher the obstruction in the intestine. An X-ray picture taken after a barium meal would show dilated coils of small bowel containing gas, and sharp horizontal fluid levels between the gas and the barium meal. The clinician would naturally consider the question of the cause of the stenosis, but in most cases no diagnosis in regard to cause could be made before operation.

At laparotomy there would be found dilated coils of small bowel and contracted empty coils of bowel and the obstruction would be located at the junction of the dilated bowel with the contracted bowel. Inspection of the bowel might enable an opinion to be given as to the cause of the stenosis. A tuberculous ulcer causes a scar which spreads circumferentially around the bowel from its antimesenteric border. In some cases the stricture of the bowel is associated with other scars of this nature on the walls of the bowel. Close inspection of the bowel might reveal tubercles on the peritoneal aspect of the scar and there might be caseating glands in the mesentery. In other cases an annular stricture is present, which must have resulted from the scarring of an inflammatory lesion. Whether the lesion be of tuberculous origin, or the non-specific granuloma, first described by Crohn (1932), would be impossible to decide from an external inspection of the bowel. Crohn's disease would be more likely if there were involvement of an appreciable segment of the bowel, but it must be conceded that Crohn's disease might not involve an appreciable segment of the bowel. Attention has been drawn in the literature to the diagnostic significance of the 'string sign' of Kantor (1934) where a trickle of barium along a stricture of the small intestine is diagnostic of the presence of Crohn's disease. A malignant growth could cause an annular stricture of the bowel, but there is usually considerable body to such a stricture from the presence of tumour tissue. Some cases might, however, simulate an inflammatory stricture. Operative relief of a stricture of the intestine could be obtained by short-circuiting the stricture by means of a lateral anastomosis, and where a stricture represents a healed scar of a past infection such treatment would cure the patient by an operation involving a minimum risk to life. The other method of treatment would be to resect the affected segment of the bowel containing the stricture with restoration of the continuity of the bowel by an end-to-end anastomosis. Where there was any possibility of the stricture being malignant such a course would be the best assurance against a possible disaster. Patients stand these surgical operations remarkably well, and convalescence is usually smooth. It is possible that with the methods of aseptic anastomosis now in vogue, even better results would be possible, with an afebrile post-operative convalescence.

When the bowel has been resected, it is possible to make a detailed examination of the

lesion. There is usually a small ulcer on the antimesenteric border of the bowel. Histological examination of the floor of the ulcer would demonstrate tuberculous granulation tissue in the case of a tuberculous lesion, provided that healing had not progressed so far as to cause replacement of the granulations by scar. In the case of Crohn's disease granulations would consist of plasma cells and young connective-tissue cells. A diagnosis of Crohn's disease would be made by exclusion; for if the lesion were tuberculous the granulations would be characteristic of tuberculosis, and if it were malignant the histological appearances would be characteristic of malignant disease.

### CASE REPORTS

#### Case 1.—Acute intestinal obstruction due to a tuberculous stricture of the ileum.

F., male Singhalese, aged 50 years, was admitted to the General Hospital, Colombo, on March 12, 1936, at 10.20 a.m. on account of abdominal pain of two days' duration. The patient was deaf and a history was difficult to elicit. The pain was circum-umbilical and colicky, coming on in bouts every few minutes and he had vomited once on the day of admission to hospital. He had not had a stool, nor had he passed flatus since the onset of the pain. While being questioned, the patient vomited watery brown fluid. The abdomen was moderately distended,

distended loop of small bowel, 6 in. long, heavy with putty-like faeces. At the distal end of this loop of bowel, there was a sudden narrowing of the lumen of the bowel by a white annular stricture. The bowel beyond the stricture was empty and contracted while the bowel above the coil containing putty-like faeces was dilated. At the site of the stricture there was a white puckered scar on the antimesenteric border of the bowel with a white streak running around the bowel on each side towards the mesenteric border. There were no other scars on the intestinal walls. The unusual circumstances of finding putty-like faeces firmly impacted over 6 in. of ileum above the stricture greatly complicated the operative procedure. A short-circuit of the ileum above and below the stricture would not have relieved the affected loop of ileum of its heavy load of faeces, and it was decided that this loop must be resected. This was done, 10 in. of ileum being removed, and the continuity of the bowel re-established by an end-to-end anastomosis. The abdominal wound was closed.

The patient made a good recovery from the operation, passing flatus on the fourth post-operative day and a solid stool on the fifth. The wound healed by first intention and the patient left hospital on March 23, 1936.

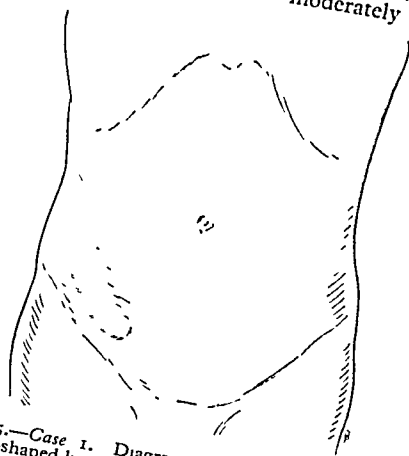


FIG. 305.—Case 1. Diagram showing the size of the sausage-shaped lump palpated in the abdominal cavity.

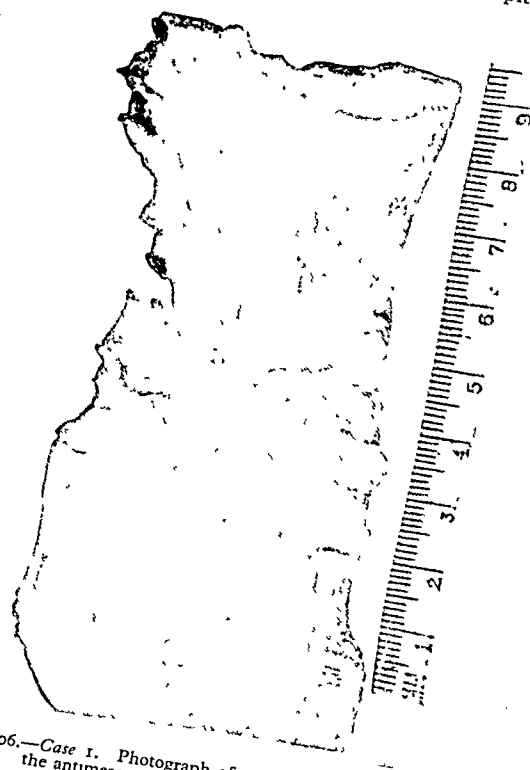


FIG. 306.—Case 1. Photograph of transverse scar on the antimesenteric border of ileum.

and through the abdominal wall there were clearly visible contracting coils of bowel arranged in a ladder pattern, hardening under the palpitating hand with each bout of pain. A sausage-shaped lump was palpable in the right iliac fossa lying parallel to the groin and about six inches long (Fig. 305). An enema was given, but the enema fluid was returned without force, and without flatus.

A diagnosis of an ileo-ileal intussusception was made, and immediate operation advised.

OPERATION.—This was carried out at 11.30 a.m. The abdomen was opened through a right paramedian incision. The peritoneal cavity was clean, there being a little excess of serous fluid in the peritoneal cavity. Contracted empty coils of small bowel were seen, with dilated loops of bowel amongst them. On exploring the right iliac fossa, there was found a

THE SPECIMEN.—This shows 10 in. of ileum, 3 in. being below the stricture and 7 in. above. The mucosa shows healthy valvulae conniventes and it is neither ulcerated nor scarred. From the peritoneal aspect there is seen a puckered scar the diameter of a lead pencil on the antimesenteric border of the bowel, with a transverse white scar passing round the bowel wall (Fig. 306).

**Commentary.**—There was in this case but a single white scar on the bowel wall, which from its position and distribution must have been produced by cicatrization of a single tuberculous ulcer of the ileum. There was found no other evidence of tuberculous

years ago by Dr. S. C. Paul for abdominal pain, and since that time had no trouble till the onset of the present illness.

**ON EXAMINATION.**—The patient was a well-nourished individual, who was perfectly comfortable



FIG. 307.—Case 2. Radiograph showing condition five hours after the administration of a barium meal. The gas in the greatly dilated small intestine with the horizontal fluid levels between the gas and the barium is well shown.

infection of the abdominal cavity. The finding of solid faeces in the ileum is unusual and it is possible that this was caused by continued inspissation of the bowel contents by absorption of water by the ileum. It is known that patients with a permanent ileostomy pass semi-solid stools after some time, and a similar adaptation must have taken place above the stricture in this case.

**Case 2.—Subacute intestinal obstruction due to a tuberculous stricture of the jejunum.**

S. A. R. A., aged 30 years, male Singhalese, was admitted on Aug. 12, 1942, to the General Hospital, Colombo, on account of severe bouts of colicky abdominal pain. At the time of admission the bouts of pain came on every ten or fifteen minutes. These pains had been noted for the last four months, at first coming on two or three times after meals and lasting on and off for two or three hours at a time. The pains had gradually come on more and more frequently. During the height of a pain, the patient could see a lump forming in his abdomen as if the bowels had become knotted. In the last two months there had been vomiting of fresh food once a day. The patient stated that he had been operated on fifteen

till the onset of a bout of pain. The pain was circum-umbilical and at the height of the pain there was visible through the abdominal wall the ladder of small-intestine peristalsis. The coils of contracting bowel could be palpated at the height of the pains, whilst between the pains the abdomen was free from tenderness, there being no lump palpable at these times. The scar of an old paramedian abdominal incision was seen. Pulse 80 and of good volume. Although it was clear that the patient was suffering from an organic obstruction of the small intestine, in view of his good general condition it was decided to operate on the patient on the next operating morning, the interval being utilized to take an X-ray picture after the administration of a barium meal. The five-hour picture (Aug. 13) shows greatly dilated loops of small bowel filled with gas and containing barium with a clear fluid level between the gas and the barium (Fig. 307).

**OPERATION** (Aug. 14).—Under light percaïne anaesthesia, the abdomen was opened through a right paramedian incision. The peritoneal cavity was clear and dry. Both dilated and contracted coils of small bowel were seen in the abdominal cavity. The dilated bowel was traced downwards and it was found

to terminate abruptly at the site of an annular stricture on the bowel wall about midway down the jejunum (Fig. 308). The rest of the small bowel was empty. No other lesion of the small intestine was noted, and there were no enlarged glands in the mesentery. The appendix was missing. Palpation of the stricture gave the feel of an indurated ring. On the peritoneal coat there was a white scar running transversely

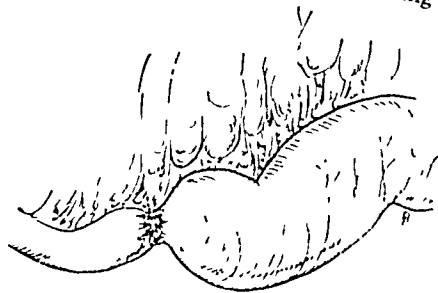


FIG. 308.—Case 2. Diagram showing annular stricture with transverse white scar found.

round the bowel at the site of the stricture. It was considered that the stricture was due to a healed tuberculous lesion, but it was felt that the possibility of the stricture being caused by a malignant growth could not be excluded. In view of this, it was



FIG. 309.—Case 2. Photograph showing puckered scar with shallow ulcer of mucosa at antimesenteric border.

decided that resection of the bowel would be preferable to short-circuiting the stricture, and accordingly 4 in. of bowel were resected, and the continuity of the bowel being restored by end-to-end anastomosis. On account of marked inequality between the lumen of the dilated proximal end and that of the contracted distal end, the excess lumen on the proximal end was closed off from the antimesenteric border. Five hours after operation the patient was complaining of severe colicky abdominal pains coming on in bouts every few minutes. His pulse was 68 and of good volume. These pains continued for nearly six hours

after operation, after which they suddenly disappeared when the patient passed flatus for the first time. Five days after operation the patient passed a large solid stool and on the next day his bowels opened again. The wound healed by first intention and the patient left hospital on Sept. 4, feeling his normal self.

THE SPECIMEN (Fig. 309).—Viewed from the peritoneal side there is an annular stricture of the jejunum with a fibrous ring going all round the bowel. On opening the bowel there is seen an annular scar on the mucosa with a small shallow ulcer on the mesenteric border of the bowel at the site of the

### Case 3.—Acute intestinal obstruction due to a tuberculous stricture of the ileum.

J. A., male Singhalese, aged 52 years, was admitted to the General Hospital on Dec. 4, 1941, under Dr. G. S. Sinnethamby, complaining of colicky diffuse abdominal pain of seven days' duration. Vomited twice. Absolute constipation. The case was referred to the writer for examination and operation.

ON EXAMINATION.—At the time the patient was having the pains every few minutes and on each occasion the ladder pattern of visible peristalsis was clearly seen. On auscultation the turbulent sounds of exaggerated peristalsis were heard. A rectal examination revealed a bulging of the rectal wall above the prostate and in the bulging area the outline of dilated coils of bowel could be distinguished. Pulse 65, temperature 98.4°. A diagnosis of organic obstruction of the lower ileum was made and an emergency operation advised.

OPERATION.—This was done an hour later under light percaïne anaesthesia. A right paramedian incision was made and the abdominal cavity opened. The peritoneum was clean and dry. The abdomen was full of dilated coils of small intestine. On exploration of the bowel, a stricture was found in the ileum, 12 in. from the ileo-cæcal valve. At this point the bowel narrowed suddenly, and the bowel below was empty and contracted, as was the large bowel (Fig. 310). The stricture was an annular one, having

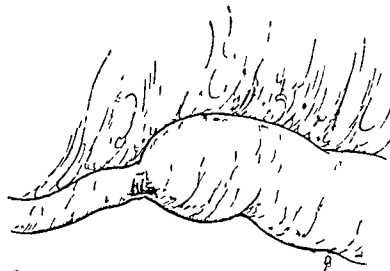


FIG. 310.—Case 3. Diagram showing bowel at site of stricture. The transverse white scar on the antimesenteric border of the bowel is shown in the figure.

a transverse white scar on the antimesenteric border extending round each side of the bowel. The mesentery of the small intestine was white and scarred, and there were a few light adhesions here and there, which were readily separated. No other scars were noted on the bowel walls. A lateral anastomosis between the ileum above and below the stricture was made and the abdominal wound closed. Six hours after operation the patient passed a large stool and another stool twelve hours

The patient made a good recovery. Nine days after operation there was a discharge of pus from the abdominal wound, but after this healing was uninterrupted. He left hospital on Jan. 7, 1942, relieved of all symptoms.

**Commentary.**—In this case the clinical picture of a lower ileum obstruction was clear, and at the operation the finding of a transverse white scar at the site of the stricture made possible a definite diagnosis of tuberculous stricture. The early passage of two large stools a few hours after operation was due probably to the vigorous peristalsis promoted by the spinal anaesthetic.

**Case 4.—Chronic intestinal obstruction due to a tuberculous stricture of the jejunum relieved by gastro-enterostomy.**

G. M. A., male Singhalese, aged 30 years, was admitted to the General Hospital on June 12, 1941, complaining of colicky diffuse abdominal pain of two months' duration, and frequency of micturition for twenty days. No nausea or vomiting. He had had similar attacks of abdominal pain of one or two weeks' duration during the past one and half years.

On examination the abdomen was soft and no lump was palpable. Per rectum the prostate was of normal shape.

Urine: Cloudy, Sp. gr. 1012, Alb. —.

Deposits: Pus cells +, field full.

Cystoscopy: Bladder normal.

Radiography: No vesical calculus seen.

The circum-umbilical pains continued on and off, but as no definite lesion was discovered the patient left hospital on June 27, promising to return for further investigation.

On Nov. 11 the patient was re-admitted on account of abdominal pains of one month's duration. The pain was circum-umbilical. The pains came on in



Fig. 311.—Case 4. Diagram showing area of induration of jejunum just beyond duodeno-jejunal flexure and the annular stricture 3 in. beyond this.

bouts and were worse after meals, coming on five minutes to half an hour after meals. No vomiting. The patient still had frequency of micturition, day 10 times, night 15 times, and a dull pain in the lower abdomen. Abdomen soft. Spleen enlarged two fingers below costal margin. On radiography after a barium meal the stomach was seen to fill well without a defect and to empty in the normal time. The duodenal cap was visualized. There was some stasis in the caecum after twenty-four hours.

Urine: Alb. nil, occasional pus cells in deposit, culture sterile.

Examination of the central nervous system revealed no abnormality.

There appeared to be two conditions in this case—the urinary trouble and the colicky abdominal pains

coming on after meals. As the abdominal pains were the more severe of the two, an operation was advised.

**OPERATION.**—Under light percaïne anaesthesia, the abdomen was opened through a midline supra-umbilical incision. The stomach, duodenum, and gall-bladder were found to be normal. The bowel was now inspected from the duodeno-jejunal flexure. The first part of the jejunum just below the flexure was indurated and pulpy for 3 in., and 3 in. beyond this was an annular stricture of the jejunum. At this site there was a transverse white scar going all around the bowel (Fig. 311). There were several scars about every 9 in. of the jejunum, becoming less and less marked lower down, and not being present in the ileum or large bowel. Many of these scars were on the mesenteric border of the bowel wall and others

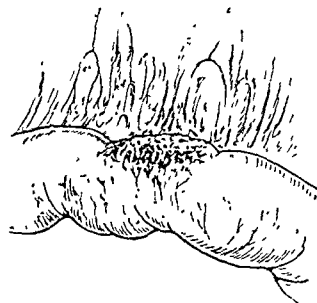


Fig. 312.—Case 4. Diagram showing scar in mesenteric border of jejunum which was oedematous. There were miliary tubercles on it, which are shown in the diagram.

on the antimesenteric border, these being transverse to the long axis of the bowel (Fig. 312). Miliary pinhead tubercles were seen on the scars in some places and the scars were oedematous. It was clear that this patient had multiple tuberculous lesions of the jejunum, and that the annular stricture within a few inches of the duodeno-jejunal flexure probably accounted for his abdominal pain. A posterior gastro-enterostomy was done between the stomach and the jejunum beyond this stricture. The patient made a good recovery from the operation. The diffuse abdominal pains were relieved after the operation, but the patient now complained of dysuria, and the pain in the hypogastrium became more noticeable.

The urine was examined for the bacillus of tuberculosis, but the test was negative.

The patient left hospital on Jan. 16, 1942.

**Commentary.**—In this case, the lesions in the jejunum with their multiple white oedematous scars, some of them transversely disposed on the bowel wall, and many with miliary tubercles in their scars, pointed clearly to the diagnosis of tuberculosis. The single jejunal stricture found in this case was so close to the duodenum that the simplest mode of relieving the obstruction was by a posterior gastro-enterostomy. It is very probable that the patient also had tuberculosis of one or both kidneys in view of this continued complaint of dysuria and pain in the hypogastrium with clear urine and a bladder normal on cystoscopic examination.

**Case 5.—Crohn's disease causing a stricture of the jejunum cured by duodeno-jejunostomy.**

H. K. D. M., aged 37, male Singhalese, was admitted to the General Hospital on Jan. 17, 1944, on account of great emaciation and persistent vomiting

of four months' duration. The patient had been advised to undergo a surgical operation for this condition one month ago, but had tried medical treatment instead. Two years previously he had a bout of pain lasting one week, but since then he had kept in good health and had had no symptoms till four months ago, when he began to vomit once in every three or four days. The vomiting had no relation to meals and the vomitus was a yellow bitter fluid. The vomiting had persisted up to the present time, coming on once in two to four days to twice a day. This vomiting had been accompanied by constipation, loss of appetite, and extreme emaciation.

ON EXAMINATION.—The patient was emaciated, his eyes were sunken, his abdominal skin had lost its elasticity, and the ribs were merely covered by skin. There was visible peristalsis of the gastric type, the waves moving from left to right across the upper abdomen.

An X-ray picture showed marked dilatation of the stomach and duodenum with retention of the barium meal in the duodenum up to five hours (Fig. 313).

OPERATION (Jan. 21).—Under local infiltration anaesthesia the abdominal cavity was opened by a

to the third part of the duodenum by a lateral anastomosis, no clamps being used (Fig. 314).

The patient made an uninterrupted recovery from this operation, and left hospital on March 5, being kept for this period in order that he might regain his lost weight by adequate feeding.

The diagnosis of Crohn's disease is suggested by the indurated salmon-pink areas of bowel, the second lesion being 1 in. long.

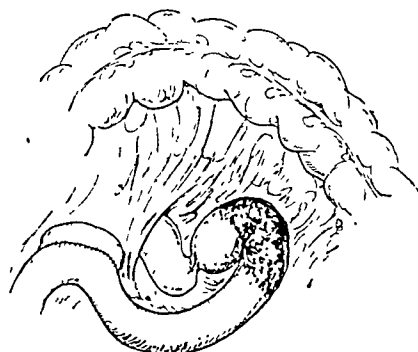


FIG. 314.—Case 5. Showing the affected areas of jejunum and the completed duodeno-jejunal anastomosis.

## DISCUSSION

The cases reported in this paper do not appear to be of common occurrence. Caplan and Roantree (1939) described 2 cases of stricture of the ileum in South Indians—one definitely due to tuberculosis and the other almost certainly of the same origin. They refer to a paper by Chi (1934), who was able to find records of only 11 cases of localized tuberculosis of the ileum reported up to that time. The pathology of non-tuberculous chronic inflammatory strictures of the intestine has still to be worked out fully. Idiopathic ulcers in both jejunum and ileum have been described by Brown (1924), Ebeling (1933), and Smith (1935). In the present state of our knowledge it would appear that such ulcers should be classified as cases of Crohn's disease. Kini (1941) described 3 cases of granulomatous ulcers of the small intestine causing annular strictures and intestinal obstruction in South Indian patients. Resection of the bowel in one of the cases made a histological examination of the ulcer possible. A section of the ulcer showed of tuberculous granulation tissue.

## REFERENCES

- BROWN, K. PATERSON (1924), *Edin. med. J.*, 31, 45.  
 CAPLAN, A., and ROANTREE, W. B. (1939), *Lancet*, 6, 9.  
 CHI, C. K. (1934), *Chin. med. J.*, 48, 291.  
 CROHN, B. B., GINZBURG, LEON, and OPPENHEIM, G. D. (1932), *J. Amer. med. Ass.*, 99, 1323.  
 EBELING, W. W. (1933), *Ann. Surg.*, 97, 857.  
 KANTOR, J. L. (1934), *J. Amer. med. Ass.*, 103, 201.  
 KINI, M. G. (1941), *Indian med. Gaz.*, 76, 662.  
 SMITH, B. C. (1935), *Ann. Surg.*, 101, 1225.



FIG. 313.—Case 5. Radiograph immediately after a barium meal. The stomach and the duodenum are dilated and full of barium. There is a stricture of the jejunum 1 in. from the duodeno-jejunal flexure.

right paramedian incision, 6 in. long and centred on the umbilicus. The small intestines were collapsed and empty. There was an annular stricture of the jejunum, 1 in. from the duodeno-jejunal flexure, and 2 in. beyond this was a second area of jejunum 1 in. long which was not normal. Both the affected areas were indurated, oedematous, and salmon-pink in colour. The glands of the mesentery of the affected jejunum were enlarged to the size of peas. The jejunum beyond the diseased area was anastomosed

## CARCINOMA OF THE ŒSOPHAGUS: RESECTION AND ŒSOPHAGO-GASTROSTOMY

BY VERNON C. THOMPSON, LONDON

IT is now thirty-one years since Torek (1913), first successfully removed a carcinoma of the œsophagus by the transthoracic approach; this patient survived for thirteen years with an œsophageal fistula in the neck connected to a gastrostomy by a rubber tube, and died at the age of 80 from pneumonia (Torek, 1927). Since then many ingenious methods of œsophagectomy have been attempted; a few, such as the pull-through technique first employed by Grey Turner (1933), have been occasionally successful, but the Torek operation with slight modifications remains to-day the standard operation for growths in the middle third of the œsophagus. Even so it cannot be claimed that any great success has been achieved. In thirty years certainly less than 100 operations of this type would seem to have succeeded. Ochsner and De Bakey (1941), in a very extensive review of the literature, state that of 58 cases reported, 41 died. Since 1941, however, several additional cases have been reported.

For growths of the lower third of the œsophagus the ideal procedure is resection of the growth with immediate restoration of continuity by anastomosis of the cut end of the œsophagus to the stomach. In 1908, Voelcker reported a successful resection of the lower end of the œsophagus with œsophago-gastrostomy through an abdominal incision. Ochsner and De Bakey (1941) stated that there had been 24 recoveries reported in the literature from this type of operation.

Resection and œsophago-gastrostomy by the transthoracic route is a more modern development and appears to coincide with the advances that have been made in recent years in thoracic surgery. Successful operations by a combined abdomino-thoracic approach were reported by Oshawa (1933). The first successful resection of carcinoma of the œsophagus with immediate œsophago-gastrostomy by the pure transthoracic route, was reported from America by Adams and Phemister (1938). Since then several cases have been reported in the American literature, and 5 successful operations by the abdomino-thoracic route have been reported by Wu and Loucks (1942) from China.

The patient whose case history is here described was shown at a meeting of the Clinical Section of the Royal Society of Medicine on October 8, 1943 (Thompson, 1943). On the same occasion Tubbs (1943) showed a patient on whom he had performed a similar operation for carcinoma of the cardia involving the lower end of the œsophagus. Steele (1943) has also reported

a successful resection with intrathoracic anastomosis for carcinoma of the œsophagus.

### CASE REPORT

**HISTORY.**—J. W., a male labourer, aged 54. In June, 1941, while eating fish and chips, he noticed sudden difficulty in swallowing. From that day he continued to have difficulty and was forced to take a soft diet. On four occasions he regurgitated food. He lost 1 st. in weight.

On Sept. 2, 1941, he was admitted to the London Hospital, where a barium swallow revealed an obstruction at the lower end of the œsophagus. He was



FIG. 315.—Radiograph showing irregular stricture at lower end of œsophagus, passing below the diaphragm and involving the stomach

referred by Dr. Horace Evans to the Department of Thoracic Surgery and transferred to an E.M.S. Thoracic Unit on Sept. 29.

**EXAMINATION.**—A thin but otherwise healthy looking man. All his teeth had been extracted but he wore satisfactory dentures. He was unable to swallow solids, but could manage fluids and semi-solid foods.

The chest appeared emphysematous, but apart from this no abnormality was detected in the heart and lungs. The vital capacity was 2600. The blood-pressure was 115/95. The abdomen was scaphoid in appearance, but otherwise normal. The urine contained no abnormal constituents. The hæmoglobin was 100 per cent. W.B.C., 13,400.



A plain radiograph of the chest showed that the lungs appeared emphysematous; and there was evidence of some pleural involvement at the left base. A barium swallow demonstrated an irregular stricture of the lower end of the œsophagus, passing beyond the diaphragm into the stomach (Fig. 315). The radiograph suggested a tumour, the outlines and extent of which were clearly shown to involve the œsophagus and the cardia.

#### OPERATIONS.—

*First Operation.*—On Oct. 7, under nitrous oxide, oxygen, and cyclopropane anaesthesia given by Dr. G. Hochschild, an exploratory laparotomy and jejunostomy were performed. A hard mass about 1½ in. in diameter was felt in the cardia extending through the diaphragm. No glandular or hepatic metastases were discovered. A Witzel jejunostomy was performed in the highest mobile part of the jejunum.

The patient was given peptonized milk by the jejunostomy from the first day, to supplement the meals he was able to take by mouth.

Forty-eight hours after operation his temperature rose to 102° and he complained of pain in his left chest. The following day he developed cough and sputum and there was evidence of consolidation in the left lower lobe. Breathing exercises, expectorants, and carbon-dioxide inhalations were given, and by the tenth day his pulmonary symptoms had subsided.

On Oct. 28 an attempt to induce an artificial pneumothorax failed, the lung appearing to be everywhere adherent.

*Second Operation.*—On Oct. 29, under nitrous oxide, oxygen, and cyclopropane anaesthesia given by Dr. A. I. Parry Brown, the œsophagus was explored by the trans-thoracic route. With the patient in the right lateral position, the left 9th rib was resected and by means of a mechanical rib spreader the chest was widely opened. The lung was uniformly adherent to the chest wall and diaphragm. The adhesions were separated with ease until an adequate exposure of the mediastinum behind the heart was obtained. The lung was displaced upwards and the mediastinum opened by dividing the pulmonary ligament. A tumour was found involving the lower 1½ in. of the œsophagus and passing below the diaphragm. The healthy œsophagus above the growth was isolated and a piece of tape passed round it. The phrenic nerve was crushed. The growth was then freed, mainly by blunt dissection, but partly by cutting between artery forceps.

The diaphragm was incised for about 4 in. from the periphery to the œsophageal hiatus. The stomach, the spleen, and the left lobe of the liver were found to be adherent to the diaphragm. When these adhesions had been separated the growth was found to involve 1½ in. of the cardia. The left gastric artery was divided, and the upper part of the stomach was brought up into the thorax. The tumour-bearing area was then resected by dividing the stomach and the œsophagus between intestinal clamps. The stomach was closed by a double layer of continuous catgut sutures. An attempt to approximate the fundus of the stomach to the cut end of the œsophagus showed that there would be very considerable tension on the anastomotic sutures. This difficulty was mainly due to adhesions round the spleen, which tended to drag the stomach back into the abdomen. The spleen was therefore removed and this resulted in a much easier approximation.

A separate incision 2 cm. long was then made in the fundus and the cut end of the œsophagus was

implanted into the stomach through this incision. Four anchoring mattress sutures of linen thread were applied at equal quadrants, taking all layers of stomach and œsophagus. The incision in the stomach was then closed round the œsophagus, using two layers of seromuscular to muscular catgut sutures. Finally, a piece of omentum was wrapped round the suture line and stitched in position. The incision in the diaphragm was sutured and closed round the stomach.

The chest was closed in the usual manner, an intercostal under-water drain being inserted.

*THE SPECIMEN.*—The specimen consists of a segment of the œsophagus and stomach measuring 5 in. in length. The proximal ½ in. is composed of healthy œsophagus, the distal 1 in. of healthy gastric



FIG. 316.—Photograph of the specimen removed.

wall. The rest of the specimen consists of a hard, ulcerated, craggy growth involving the whole circumference of the œsophagus and stomach and infiltrating the whole thickness of their walls, but not extending beyond the muscular coats. Four small lymph-nodes are attached to the specimen. (Fig. 316.)

Histological examination showed the growth to be a squamous carcinoma with considerable keratinization. Of the four lymph-nodes, one contained a little growth.

*POST-OPERATIVE COURSE AND MANAGEMENT.*—A blood transfusion by the drip method, which was started at the commencement of the operation, was continued when the patient returned to the ward until 1500 c.c. of blood had been given. Three litres of intravenous fluid were given daily until the fifth day, in the form of one litre of 5 per cent glucose in physiological saline and two litres of 5 per cent glucose in distilled water. Feeding by the jejunostomy was started on the second day. Nothing was given by mouth until the third day, when he started to take small quantities of water. The jejunostomy feeds were continued and the amount taken by mouth gradually increased; but no solids were given for two weeks. The jejunostomy tube was removed at the end of a month and thereafter the wound closed at once without leakage. He was then given a normal diet and was able to eat a beefsteak with great relish.

His convalescence after the operation was quite uneventful; drainage from the intercostal tube practically ceased on the sixth day. The under-water seal was discontinued on the tenth day, and the tube was gradually shortened until it was finally removed one month later.

In spite of the fact that he had developed pulmonary complications after the operation of jejunostomy, no similar complications followed the major operation.

An X-ray examination on Dec. 16, 1941, showed the fundus of the stomach above the diaphragm, the stoma appeared satisfactory, and there was no delay at the lower end of the œsophagus (Fig. 317).



FIG. 317.—Radiograph showing the condition after operation. The fundus of the stomach is above the diaphragm

He was discharged from hospital on Jan. 16, 1942.

**AFTER-HISTORY.**—The patient was subsequently examined at intervals. Soon after he left hospital he developed arthritis in both shoulders, which prevented him from returning to work; but this condition responded slowly to treatment and from September, 1942, to September, 1943, he worked regularly in a factory for 12 hours a day, 6 days a week. He complained occasionally of slight abdominal discomfort after a heavy meal; but he ate anything he chose. On only one occasion did he notice difficulty in swallowing; this occurred in November, 1942, when his gums were sore and he was unable to wear his dentures and chew his food. A barium swallow in May, 1943, showed that there was no delay at the stoma, which appeared satisfactory.

In October, 1943, he developed an attack of acute bronchitis and had to cease work. He recovered from this attack in ten days, but was unable to return to work on account of general weakness.

On Nov. 26, 1943, he was re-admitted to hospital complaining of pain on micturition and defæcation, loss of appetite, and general weakness. His swallowing was normal. On examination he appeared very wasted. There was no obvious involvement of

supraclavicular lymph-nodes. The liver could not be felt and there were no signs of free fluid in the abdomen. On rectal examination a hard, fixed, tender mass was palpable in the rectovesical pouch.

On Dec. 16 he died, two years and six days after his operation.

**AT AUTOPSY** (Dr. W. W. Woods, The London Hospital—P.M. 242/43).—*Bronchopneumonia. Wasting. Secondary carcinoma of stomach, lymphatic glands, and peritoneum.*

Old healed anastomosis between œsophagus and stomach at a point 22 cm. from the lower border of the cricoid cartilage and a few cm. above the diaphragm; very thin scar at the stoma (3.5 cm. in circumference); wall of œsophagus and stomach at the anastomosis flexible, unthickened, and entirely free from growth. No dilatation or hypertrophy of œsophagus above the anastomosis; circumference of œsophagus 3.7 cm. in the lower part and 3 cm. in the upper part; œsophageal muscularis 0.25 cm. thick. Very little secondary growth in the thorax: one lower mediastinal gland (1.0 × 0.7 cm.) full of growth, and a few nodules (0.5 × 0.3 cm.) in one gland near the tracheal bifurcation. Slightly ulcerated plaque of secondary growth (10 × 5.5 cm.) in stomach, saddling lesser curve, its upper end being separated from the anastomosis by a stretch of stomach wall (1 cm. long) free from growth, its lower end being 8 cm. from pyloric sphincter; extension of this gastric growth into lesser omentum as an area of diffuse carcinomatous infiltration, and into pancreas and left suprarenal as small superficial areas. Confluent nodules and plaques of growth in serosa of stomach and in greater part of peritoneal surface of diaphragm, a few (0.3 cm. diam.) in pleura of right dome of diaphragm, a few (1 cm. diam.) scattered in parietal peritoneum and in serosa of large intestine, especially around appendix; thin plaques of growth covered with organizing fibrin in rectovesical pouch. No ascites. Growth throughout a bunch (4 × 2 cm.) of cœliac glands, a few glands (1 cm. diam.) along greater curve of stomach, and numerous lumbar glands (4.5 × 2.2 cm.). About 25 nodules of growth (0.8 cm. diam.) scattered in liver. A few small flecks of pink marrow in shaft and neck of femur. Red marrow in sternum. Obliteration of lower two-thirds of right pleural cavity, and all left, by fibrous adhesions; adhesions very tough over the operation scar in seventh left intercostal space; cutaneous part of this scar a very thin line (18 cm. long). Emphysematous cysts (1 cm. diam.), anthracosis and slight fibrosis in apex of each lung. Calcareous nodule (0.3 cm. diam.) in gland of bifurcation of trachea. Œdema of lungs. Numerous nodules of bronchopneumonia in lower lobe of right lung. Omentum adherent to a left upper paramedian laparotomy scar. Spleen absent. No accessory spleen. Brown atrophy of heart. Very wasted man.

Microscopical sections were made of lumbar glands and liver. They show squamous-cell carcinoma mostly composed of considerably atypical cells, though also containing large areas of keratinization.

## DISCUSSION

**1. The Incision.**—The fact that this patient developed pneumonia after a simple laparotomy and jejunostomy, and yet had no infection of the lung after the major operation by a thoracic approach, strongly supports the belief that pulmonary complications are more likely to occur after abdominal than after chest incisions.

This experience is a strong argument against the abdominal or the combined abdomino-thoracic approach; particularly as the exposure obtained was excellent throughout and no difficulty was encountered on that account.

**2. Preliminary Jejunostomy.**—Most of the patients with carcinoma of the œsophagus are wasted and are often dehydrated. A preliminary jejunostomy is a great advantage in feeding both before and after the resection of the growth. Moreover, laparotomy allows an adequate examination of the liver and subdiaphragmatic region. A gastrostomy is not desirable as it interferes with the subsequent mobilization of the stomach.

**3. The Anastomosis.**—Since a paper was published by Carter and his associates (1941) recording their experiences with two patients and their subsequent experimental work on dogs, the method of implanting the œsophagus into the stomach has not been regarded with favour. In their experiments no sutures were passed through the œsophageal mucosa, and the free end of the œsophagus retracted and formed a stricture. If the end of the œsophagus is 'splayed out' inside the stomach by through-and-through mattress sutures, as in the operation here described, retraction is prevented. In this case in spite of removing the spleen there was some tension on the anastomosis and it is probable that if the implantation method had not been employed the anastomosis would have leaked.

At post-mortem examination the stoma was 3.5 cm. in circumference; it was represented by a thin pliable scar with no undue fibrosis or induration. Regurgitation of gastric contents after œsophagogastrostomy, particularly when the patient is lying down, has been reported by Phemister (1942) and others. These symptoms were not experienced at any time by the writer's patient. It would seem that regurgitation is most likely to occur through a large stoma and that a narrow stoma is an advantage, providing it causes no delay to the passage of food.

**4. Scope of the Operation.**—The operation described has proved to be a practical and successful procedure. Its frequency and success in the future depend, like operations for carcinoma in other parts of the body, on early diagnosis.

The Registrar-General (1944) gives the following statistics for deaths from cancer in England and Wales for the years, 1920, 1930, and 1940.

Year	All sites	Œsophagus	Ratio of Œsophagus to All Sites
1920	42,420	1,795	0.040
1930	56,254	2,217	0.039
1940	68,740	2,321	0.034

These figures show that although the number of deaths from carcinoma of the œsophagus is increasing, the ratio of these deaths to deaths from carcinoma of all sites has diminished since 1920.

Ochsner and De Bakey (1941), basing their figures on a collected series of 8572 cases, state that 42.8 per cent of carcinomas of the œsophagus occur in the lower third. It would thus appear that in England and Wales in 1940 there were about 1000 persons who might have been given a chance of survival by the type of operation described.

Carcinoma of the cardiac end of the stomach also presents a field in which the same operation can be applied.

## SUMMARY

A case of carcinoma of the lower end of the œsophagus involving the stomach is described. After preliminary jejunostomy, the growth was resected and œsophago-gastrostomy was performed through a thoracic incision. The patient swallowed normally until his death 2 years and 6 weeks later from multiple intraperitoneal metastases.

The operation was performed in October, 1941, and would appear to be the first successful one of its kind carried out in this country.

I wish to express my thanks and appreciation of their help to Dr. G. Hochschild and Dr. A. I. Parry Brown for the anaesthetics; to Dr. L. C. Blair for the X rays; to Dr. W. W. Woods for the post-mortem report; and to my house surgeon, Mr. H. G. Eastcott, for his careful attention to detail in the pre- and post-operative treatment of the patient.

## REFERENCES

- ADAMS, W. E., and PHEMISTER, D. B. (1938), *J. thorac. Surg.*, **7**, 605.  
 CARTER, B. N., STEVENSON, JEAN, and ABBOTT, O. A. (1941), *Ibid.*, **10**, 440.  
 OCHSNER, A., and DEBAKEY, M. (1941), *Ibid.*, **10**, 401.  
 OSHAWA, T. (1933), *Arch. jap. Chir.*, **10**, 605.  
 PHEMISTER, D. B. (1942), *J. thorac. Surg.*, **11**, 484.  
 Registrar-General's Statistics (1944), personal communication.  
 STEELE, G. H. (1943), *Lancet*, **2**, 797.  
 THOMPSON, V. C. (1943), *Proc. R. Soc. Med.*, **37**, 37.  
 TOREK, F. (1913), *Surg. Gynec. Obstet.*, **16**, 614.  
 — (1927) *Nelson Loose-Leaf Living Surgery*, **4**, 212.  
 TUBBS, O. S. (1943), *Proc. R. Soc. Med.*, **37**, 39.  
 TURNER, G. GREY (1933), *Lancet*, **2**, 1315.  
 VOELCKER (1908), *Verh. dtsh. Ges. Chir.*, **37**, 126.  
 WU, Y. K., and LOUCKS, H. H. (1942), *J. thorac. Surg.*, **11**, 516.

# PRELIMINARY REPORT ON THE USE OF WHOLE SKIN-GRAFTS AS A SUBSTITUTE FOR FASCIAL SUTURES IN THE TREATMENT OF HERNIÆ

BY GEORGE B. MAIR

WOODEND AND OLDMILL E.M.S. HOSPITALS, ABERDEEN

BRIGADIER EDWARDS (1943), in this JOURNAL, has exposed in masterly fashion the modern views on the treatment of inguinal herniæ.

The position is that the Bassini operation, with all its modifications, is not only inefficient, but actually harmful, and should be abandoned. In its stead there are two alternatives: simple herniotomy, where high excision of the sac is combined with repair of the torn or weakened fascia transversalis; and the second, or plastic, where living fascial sutures are used to narrow the internal abdominal ring, and to strengthen the weakened posterior wall of the inguinal triangle.

Edwards's paper should be read as a background to this, which is distinctly a preliminary report suggesting that the use of whole skin-grafts inlaid under extreme tension and in such a fashion as to protect the posterior wall of the inguinal canal, and narrow the internal ring, may be superior to fascia in most respects. The method has been used for cases where fascia was formerly indicated, and a history of the investigations which have been in progress in Aberdeen during the past year will be detailed.

First, however, it is necessary to discuss the position which the use of fascia holds, and to note its advantages and disadvantages.

**Use of Fascia in Herniæ.**—The indications for the use of fascial sutures are:—

1. All recurrent herniæ of any type.
2. All primary direct inguinal herniæ.
3. All primary oblique inguinal herniæ where there is muscle atrophy and weakness of rings and posterior wall.
4. All funicular or 'saddle bag' types.
5. As the final stage in the Mayo repair of umbilical herniæ.
6. As the final step in the repair of large ventral or incisional herniæ.

It is thus recognized that fascia is reserved for those cases which are most likely to recur, and in those subjects whose physique is prejudicial to the success of a physiological repair. It might then be expected that cases dealt with by fascia would show the higher recurrence rate.

Follow-up recurrence figures show wide variation in different clinics and are influenced by many variable factors. Despite the difficulties attendant upon acceptance of many published figures, certain facts emerge clear. The recurrence rate varies in the case of indirect inguinal hernia up to 30 per cent, with an accepted average of 12 per cent for the Bassini operation.

McCloskey and Lehman (1940) analysed the results in different American clinics, and found that with fascia, recurrences varied in different clinics from between 3 and 4 per cent for the indirect, to between 7 and 9 per cent for the direct, varieties. These figures suggest that fascia, though it be used in the less favourable type of case, definitely reduces the incidence of recurrence.

Much depends upon the time interval before re-examination. It is accepted that at least 75 per cent recur within the first year, and at least 60 per cent within the first six months (Page, 1943; Edwards, 1943; Judd, 1908; Erdman, 1923).

Fascia does, however, have certain disadvantages:—

1. The McArthur method does not give enough fascia to fulfil the requirements of the average case, and is applicable mainly to the inguinal type. For a large hernia the method is not ideal.

2. The Gallie technique involves either an extensive wound in the thigh, or a small incision combined with the use of a fasciotome. In either case there is a risk of post-operative pain referred to the thigh and hip-joint of the affected side, and the possibility of obvious muscle hernia. This pain may be quite intractable, is aggravated by exercise, and, in my experience, occurs in 25 per cent of subjects. The aetiology of this pain is obscure, and in those cases where a workman's compensation suit is impending, or in Service personnel, it may be a great annoyance.

3. Infection of the wound in the abdomen is fairly common. Bendick (1937) found sepsis to be present in 7.9 per cent of his cases where autogenous fascia had been used, and in 12.1 per cent where ox fascia was used.

4. Fascia will unite to fascia under considerable tension (Law, 1924) and it may be applied under tension to unite the conjoined tendon to Poupart's ligament, or, it may be darned loosely between the two structures. In either case there are potential gaps between the strands of fascia, and direct recurrences may develop.

In several cases operated on by myself, the sac had clearly insinuated its way through a gap in the fascial strands which in other parts had effected a powerful reinforcement.

5. The needle used for the Gallie method is large, and apt to traumatize the inguinal ligament. There is also a risk of penetrating the femoral vein. This complication has been frequently

mentioned in the literature (Robitshek, 1925), and in one example which came to my notice death resulted on the operating table.

6. Finally, there remains a substantial recurrence rate. Even the best figures available are too high, and provide room for consideration as to how they may further be reduced.

**Cutis Graft Repair.**—Rehn (1914) and Loewe (1913) advocated the 'cutis graft method for the repair of anatomical defects in post-operative herniæ,' and, of these, Rehn was the first to apply the principle clinically. Cutis contains all the elements of the skin excepting the epidermis, it is elastic, inherently active, and composed of a rich network of connective-tissue fibres. After transplantation, according to Uihlein (1939), these inherent factors persist in the metamorphosis of the graft, and, owing to the stimulus initiated and maintained by the tension under which the graft is sutured, a metaplasia into stout connective tissue takes place.

Rehn and Schwartz, quoted by Uihlein (1939), performed a tenotomy of the tendo Achillis in a dog, and repaired the defect with cutis graft. They found that a gradual metamorphosis took place after ten weeks into a tendon difficult to differentiate from ordinary tendon.

Rehn applied his cutis graft, which he took from the thigh, into the defect requiring plastic repair, and attached it under a maximum degree of tension to its surrounding structures by interrupted sutures. The graft was cleared so far as possible of epidermis.

Uihlein operated upon two patients who had submitted to a cutis graft repair four years earlier. Sections removed for examination showed a complete metamorphosis of the transplant. The grafts represented normal connective tissue with its fibrous and fatty components, blood-vessels, and nerves. No hair follicles or glandular tissue could be identified, and there was no evidence of cyst formation, either macroscopical or microscopical. No scar tissue was seen in the sections examined.

Rehn used this method in 65 gross post-operative herniæ with 6 poor late results. There were a further 39 operations where cutis was used to fill in a tissue defect, and of the total of 104 operations for various purposes, 15 were complicated by wound sepsis.

Cannaday (1943) and his surgical associates in the Charleston General Hospital used the method in 37 cases, of which 27 were herniæ of various types. These workers applaud the principle, state that cutis is superior to fascia, find that the graft heals firmly and promptly, and commend the fact that it is easily obtainable in portions as large as necessary for any given case.

Neither Cannaday and his co-workers nor Rehn and his associates have investigated with detail the histology of their grafts, but they are agreed that clinically the results are excellent.

Certain plastic surgeons (Eitner, 1920; Peer and Paddock, 1937; Peer, 1940), however, have studied the subject at length, but only in buried implants not sutured under tension. They found that despite every attempt to remove the epidermis, apices of hair follicles and sweat glands remained in the grafts, and that when implanted, these structures disappeared and the grafts were gradually transformed into fibrous tissue. The grafts fused with their surroundings through the mechanism of inflammation and repair associated with aseptic wound healing.

The investigations raised the old question as to the danger of epidermoid cyst formation, and this is an objection which is frequently raised to the use of cutis implants.

There is insufficient space in this paper to discuss this problem, but work done suggests that the risk of an inclusion cyst is negligible when the graft has been inlaid under tension (Rehn, 1914; Loewe, 1913; Uihlein, 1939; Cannaday, 1943; Peer and Paddock, 1937). In buried epidermal strips, however, merely inlaid into muscle or fat, and not under tension, inclusion cysts may be found (Garre, 1894; Kaufman, 1884; Schweninger, 1884; Hesse, 1912; Pels-Leusden, 1905; Zimches, 1931).

The method adopted by Rehn has clinically one decided disadvantage. The prepared thigh has an area of epidermis removed from it by a Thiersch razor, and from this denuded part the cutis graft is cut. Edges of the resulting wound are devoid of epidermis, and are closed as well as possible. Yet healing is slow, and, in any case, time is lost in the preparation of the graft.

The question arose in the author's mind as to whether it was really necessary to remove the epidermis, and with that end in view he investigated the use of whole-skin implants sutured under tension, in rabbits and in guinea-pigs. At the same time the operation has been applied clinically to a considerable number of herniæ where fascia otherwise would have been used. The results to date will be shortly indicated.

### WHOLE SKIN-GRAFT IMPLANTS

In 1938 the author, whilst repairing a very large ventral hernia in a woman aged 64, for the first time implanted a large whole skin-graft, having excised and closed the redundant peritoneum. The graft was sutured to the anterior aspects of both rectus sheaths and to the linea alba. The graft measured some 4 in. by 5 in., and was taken from redundant skin excised by an elliptical skin incision. The repair was firm and satisfactory. Eighteen months later there was no recurrence or other complication. Between 1938 and October, 1943, a similar method of repair was adopted in 7 large ventral, 3 umbilical, and 1 epigastric hernia. In none was there any complication during the early post-operative period, but unfortunately, owing to the war, none of the cases could be followed up

for more than a few months. The immediate results, however, had been so encouraging that it was determined to apply the same method to the repair of inguinal herniæ and to investigate the histology of the implants.

The rabbit was chosen as being a suitable animal for the work. An incision was made over the lumbar vertebral spines, the lumbodorsal fascia exposed and a portion excised. The defect was repaired by a whole skin-graft from which hair had been shaved, cut from the edges of the wound, and sutured under a high degree of tension to the adjacent aponeurosis. Sections of normal rabbit skin were studied for comparative purposes.

Five months later, it was found that sebaceous glands, hair follicles, and epidermis had entirely disappeared, that hairs had been surrounded by a massive foreign-body reaction, and that this in turn was being encapsulated off by a firm fibrous stroma. Macroscopically at five months it was very difficult to determine the margin of the graft, this being so firmly attached to its surroundings and so closely resembling dense normal fascia in appearance. The degree of metaplasia was striking.

Microscopically, however, dermal elements could be identified apart from the hair remnants. Atrophied sweat glands were detected, and a few dermal papillæ in a similar state of degeneration. The dermis showed a dense infiltration with fibrous tissue and impressive degree of vascularity. The margins of the graft were firmly united to adjacent fibrous tissue, and vascular septæ infiltrated deeply from the graft to subjacent muscle. A number of small, rounded, and encapsulated structures were noted which appeared to be masses of cornified epithelium arranged in whorls.

In sections studied after three weeks, the graft had materially altered macroscopically and closely resembled white fibrous tissue. Microscopically all elements of the skin could be

and insertion of rectus sheath in the pubis. It was not possible to identify with assurance where the graft ended and normal tissues began as the degree of metaplasia into tissue closely resembling that to which the implant was sutured was so striking. The appearance closely approached that of a normal inguinal canal, and the dense fibrous-tissue formation and deformity of normal anatomy, which is so striking a feature of recurrent fascial herniæ, was absent. A section was removed for examination. The histology was that of highly vascular connective tissue, in which no dermal or epidermal elements could be identified. The graft was richly infiltrated with collagen and elastic fibres, and there was firm adhesion to the underlying muscle. No trace of even microscopic cyst formation was found, but a number of giant cells were observed. No hair remnants could be identified.

The animal experiments are being continued, and in a later report the findings will be submitted. No contra-indication to the use of the grafts in the human subject has been found by this method to date.

#### CLINICAL APPLICATION OF THE PRINCIPLE

In a series of 70 inguinal herniæ, direct, indirect, and recurrent, 6 umbilical, 10 ventral,

Table I.—OPERATIONS IN WHICH WHOLE SKIN-GRAFTS WERE USED

TYPE OF HERNIA	NUMBER	AVERAGE AGE
Indirect inguinal	45	43.4
Recurrent indirect inguinal	2	27.5
Direct inguinal	16	41.2
Indirect-directing	7	46.5
Umbilical	5	44.0
Recurrent umbilical	1	55.0
Ventral	10	39.9
Epigastric	1	38.0
Femoral	1	39.0

Table II.—LENGTH OF TIME SINCE OPERATION, UP TO JULY 31ST, 1944

Months	1	2	3	4	5	6	7	8	9	12	15	18	24	24-36	36-48	60
Number	8	4	13	7	13	9	5	10	6	1	1	1	2	3	4	1

identified, but a fibroblastic reaction was in process and granulation tissue apparent at the margins of the implant. No trace of epidermoid cyst could be detected.

Sections removed at other stages showed features intermittent between the two extremes described.

The opportunity arose to explore an inguinal canal in the human subject into which a whole skin-graft had been sutured for a large direct hernia three months earlier. The graft was very firmly attached to Poupart's ligament, aponeurotic medial aspect of the internal oblique,

Table III.—COMPLICATIONS

Sepsis	2 cases. Cleared, 21-28 days
Chests	2 cases bronchitis, mild
Others	One scrotal hæmatoma. Cleared

1 epigastric, and 1 femoral, repair has been performed by means of a whole skin-graft. There have been 2 cases of mild sepsis which have cleared up, the first under three weeks and the second under four. One scrotal hæmatoma developed and there have been 2 cases of

post-operative bronchitis, which cleared up within a few days.

The results have been satisfactory, but, of course, much more time must elapse before recurrence figures can be submitted.

### TECHNIQUE OF OPERATION

**Skin Preparation.**—It is suggested that the skin chosen for the purpose, coming as it does from the vicinity of the symphysis pubis, is potentially infected, and that even if the surface be sterile, organisms may lurk in the depths of the hair follicles. Proof of the safety of using this skin lies in the results of experience. The method has been used in 88 cases with impunity.

The method of skin preparation is first of all by careful shaving, followed by scrubbing with ether soap and warm water for ten minutes. Spirit compresses and a sterile double hip spica bandage are then applied. The procedure is repeated daily for three days in all.

Before operation, in most of my cases, a culture of organisms from the skin was taken. Only a few showed any growth, and these mainly scanty colonies of *Staph. albus*.

**Anæsthetic.**—Gas, oxygen, and ether, with preliminary premedication of omnopon and scopolamine 3-4 c.c. is entirely satisfactory. For ideal relaxation an inhalation anæsthetic is essential.

**Incision.**—The incision is fashioned to enclose an ellipse of skin which is at least 2 in. long and approximately 1 in. at the broadest diameter. It extends from the symphysis pubis upwards and laterally, parallel to Poupart's ligament, for 3 or 4 in.

The skin with attached subcutaneous tissue is removed and immersed in warm normal saline solution until required.

The external oblique is incised in the usual way and the flaps reflected to expose the inguinal canal and spermatic cord. The superior flap of the aponeurosis is detached for a distance of approximately  $\frac{1}{2}$  in. from its pubic connexion, in order the better to expose the area to which the graft will be sutured medially. This having been done, the cord with cremaster muscle is lifted from the canal, and both are separated clearly from the floor, and from adhesion to the inguinal ligament, from the internal ring to the pubic end. It is essential to clear the area thoroughly, and this is readily done by clean firm sweeps with a gauze swab (Pitzman, 1919).

The cremaster and coverings of the cord are incised in the usual way, the sac dissected clear, and removed by ligation and excision at as high a level as possible.

The next step is to buttress the fascia transversalis, and to narrow the pillars of the internal ring by carefully inserted sutures, thus forming a firm support for the graft.

The repair of the incision in the coverings of the cord is made with a running suture, and attention turned to the graft.

The ellipse of skin will be found to have shrunk considerably in size. The extremities are seized by Allis forceps and the subcutaneous fat rapidly dissected away. The pointed extremities of the ellipse are then chopped off, so as to leave a free end of at least  $\frac{1}{2}$  in. at one end, and  $\frac{1}{4}$  in. at the other. The larger end is then incised vertically along from its midpoint for a distance of approximately  $\frac{1}{2}$  in. to  $\frac{3}{4}$  in., and each tail of skin grasped at its tip by Allis forceps. The whole is then laid into the inguinal canal and the inferior forceps placed below the retracted cord. The forceps are then pulled upwards and laterally so that the apex of the V thus formed grips the internal ring.

The medial margin of the graft is sutured by three stitches—to the lower anterior aspect of the rectus sheath, the fascia over the symphysis pubis, and the extreme medial edge of Poupart's ligament. Care is taken that the graft is stretched taut and that it well overlaps the pubis and rectus.

The superior Allis forceps are then drawn gently but firmly upwards and laterally to stretch the superior edge of the graft tightly. The end of the skin pedicle is now sutured to the medial aponeurotic expansion of the internal oblique. The lower skin pedicle is then also drawn outwards and the extremity sutured to the shelving inner margin of Poupart's ligament at least  $\frac{1}{2}$  in. above the level of the internal ring. Sutures are placed at intervals of about  $\frac{1}{4}$  in. along the lower edge of the graft to anchor it to Poupart's ligament, and care is taken that the ligament is sutured as near the floor of the canal as possible. The final row is applied to the superior edge of the graft, and fixes it to the aponeurotic medial edge of the internal oblique very close to the lateral margin of the rectus sheath.

The outer aspect of the graft is then sutured, joining the two pedicles together lateral to the internal ring, and in such a fashion as to form a skin plaque lateral to it as well as medial, forming another ring of skin over the internal muscular ring, and causing the cord to arch slightly upwards in its course from the ring to the canal. (Fig. 318.)

In inserting the superior row of sutures and those joining the two skin pedicles, care is taken to ensure that the graft is sutured under great tension to its attachments. Thirty-day chromicized catgut is used for suturing the graft.

A fine layer of sulphonamide powder is insufflated on to the surface of the graft and the surrounding tissues, the external oblique is closed, and the skin sutured with interrupted fine silk gut.

The patient is allowed up on the twentieth day. It is established that fascia requires three weeks to heal firmly, and there can be no point in permitting freedom of movement before that day.

In this description of technique no mention has been made of the many difficulties which may confront the operator. But it is emphasized

that as the whole skin-graft is advocated for use in large and difficult cases, it follows that difficulties will be encountered, and they are all readily capable of being surmounted by this new method.

The same principles can be adopted for direct herniæ, and can easily be used as a final reinforcement for umbilical, ventral, or epigastric herniæ,



FIG. 318.—The graft has been sutured into position. The flaps of the external oblique aponeurosis are held retracted by mosquito forceps. Note the two skin pedicles stitched together lateral to the internal ring, and that the graft is stretched tightly over the entire posterior wall of the canal.

and in fact, one of the main attractions is the general applicability of this method to any type of hernia.

#### COMMENT ON THE OPERATION

It must be recognized that a certain amount of experience with the method is necessary before mastering the technique. So far as duration of operation is concerned, in my first seven or eight cases my time was generally fifty minutes. Since then it has become less, and for the last fifty I have rarely required over half an hour to perform any variety of primary inguinal herniorrhaphy. Recurrent herniæ, of course, take somewhat longer.

When correctly bestowed, the graft affords protection to the entire inguinal canal, and narrows the internal ring, but care must be taken not to narrow it too much lest later varicocele or testicular atrophy develops. The apex of the V in the graft should fit snugly into the muscle of

the internal ring on its inferior aspect, and the cord should emerge smoothly, but with a slightly altered direction, from the ring over the edge of the skin-graft, into the canal.

In preparing the bed for the graft it is essential to obtain a thoroughly good view of the anterior aspect of the symphysis and the lower margin of the rectus abdominis. If attention is given to these points, the graft will give protection to the medial margin of the canal where direct hernia is so prone to develop.

In my experience the operation takes less time to perform than a fascial repair, and the finished immediate result appears to be stronger than that presented by fascia.

There is never any difficulty in obtaining closure of the skin wound even after removal of the graft.

Finally, my impressions to date are that the method is excellent, and that post-operative complications are fewer than when fascia is used. It is too early to give figures of recurrence or late post-operative morbidity, and it is again emphasized that this is a preliminary report. Detailed analysis of the results will be presented in due course, and compared with those for fascial repairs, Bassini operations, and simple herniotomies, as performed in Woodend and Oldmill hospitals.

#### REFERENCES

- BENDICK (1937), *Ann. Surg.*, **106**, 333.  
 CANNADAY (1943, a), *Amer. J. Surg.*, **59**, 409.  
 — (1943, b), *Ann. Surg.*, **115**, 775.  
 EDWARDS (1943), *Brit. J. Surg.*, **31**, 122.  
 EITNER (1920), *Med. Klin.*, **4**, 93.  
 ERDMAN (1923), *Ann. Surg.*, **77**, 171.  
 GARRE (1894), *Beitr. klin. Chir.*, **11**, 524.  
 HESSE (1912), *Ibid.*, **80**, 494.  
 JUDD (1908), *J. Min. med. Ass.*, **26**, 56.  
 KAUFMAN (1884), *Virchows Arch.*, **97**, 236.  
 LAW (1924), *Ann. Surg.*, **79**, 250.  
 LOEWE (1913), *Munch. med. Wschr.*, **24**, 1320.  
 MCCLOSKEY and LEHMAN (1940), *Ann. Surg.*, **3**, 610.  
 PAGE, MAX (1943), *Proc. R. Soc. Med.*, **36**, 185.  
 PEER (1940), *J. Amer. med. Ass.*, **115**, 357.  
 PEER and PADDOCK (1937), *Arch. Surg.*, **34**, 268.  
 PELS-LEUSDEN (1905), *Dtsch. med. Wschr.*, **31**, 1340.  
 PITZMAN (1919), *Surg. Gynec. Obstet.*, **28**, 329.  
 REHN (1914), *Munch. med. Wschr.*, **1**, 118.  
 ROBITSHEK (1925), *Minn. Med.*, **8**, 160.  
 SCHWENINGER (1884), *Charité-Ann.*, **11**, 642.  
 UHLEIN (1939), *Arch. Surg.*, **28**, 118.  
 ZIMCHES (1931), *Frankfurt. Z. Path.*, **42**, 203.



## COMPLETE RUPTURE OF THE PANCREAS

By J. F. CURR

TEMPORARY ASSISTANT SURGEON, ROYAL INFIRMARY, EDINBURGH, AND LEITH HOSPITAL

ANY type of injury of the pancreas is rare, and recently I have had the opportunity of operating on a young man with a complete rupture of the pancreas due to a subcutaneous injury, an excellent recovery taking place.

## CASE REPORT

**HISTORY.**—J. C. W., a male aged 20, of slim build but good physique, was admitted to Leith Hospital on Dec. 21, 1943. In the course of his duties he was walking backwards in the rear of a reversing lorry, directing the driver, when he was unexpectedly pinned between the back of this lorry and the back of a stationary lorry. The lower part of the chest and the upper abdomen were forcibly compressed, but only for a matter of seconds, as the driver at once noticed the danger and released the pressure by moving forwards. A momentary severe pain was felt at the time of the impact, but it passed off immediately. The patient was able to walk away from the scene of the accident, was then driven to the hospital nearby, and actually walked unaided through its doors half an hour after the injury.

**ON EXAMINATION.**—There was no sign of any vertebral, rib, or other bony injury, and there was no external bruising of the chest or abdomen. A moderate degree of shock was present, the pulse-rate was 80 per minute, the temperature  $97.4^{\circ}$ , and the respirations were 30 per minute, shallow, and painful if encouraged to be deep. There was a complaint of epigastric discomfort and of slight pain in the right shoulder. The movements of the abdominal wall were restricted during respiration, tenderness was present in the epigastrium, and there was slight generalized guarding of all the abdominal muscles. The urine was normal.

The patient was at once admitted to a surgical ward and the state of shock passed off without any special methods of treatment. A careful watch was kept and the condition remained quite satisfactory for three hours. Thereafter, the pulse-rate rose in the next hour from 80 to 90, and the following hour still more rapidly to 110 per minute, during which time a blood transfusion had been started and arrangements made for operation.

Vomiting had never occurred, but the upper abdominal and right shoulder pains were now quite severe. Movements of the abdominal wall during respiration were absent, rigidity and tenderness were generalized, signs of free fluid were demonstrable, and there was no loss of liver dullness. There was thus definite evidence of some severe abdominal injury, but an exact diagnosis could not be made, although a rupture of the liver, spleen, or mesentery was considered most likely. In spite of a continuous blood transfusion, the pulse-rate was still rising, and had reached 120 per minute by the time the operation was started, six hours after the injury.

**AT OPERATION.**—An open ether anaesthetic was administered, and the abdomen was opened through an upper left paramedian incision. On entering the peritoneal cavity, a tremendous amount of fresh blood was found lying free in all the peritoneal compartments, and, in spite of suction and mopping, the

blood rapidly welled up into the wound from every direction, so that at first there was great difficulty in carrying out an exploration. There was no sign of any free gastric or intestinal contents and examination of the liver, spleen, kidneys, and small intestine was negative. A tear 1 in. long was found in the lesser omentum near the stomach, but the stomach was not damaged; bleeding vessels were ligated and the tear was repaired. The inferior surface of the transverse mesocolon was inspected and revealed an irregular rent, about 3 in. long, involving the base of the mesocolon but not reaching the bowel, which was intact. The rent was immediately to the left of the undamaged middle colic artery, but a branch of it was completely severed, calling for ligation of both ends.

Further examination at the base of the mesocolon showed an extraordinary injury. The pancreas was found to be completely split into two parts, as though by a sharp knife, the line of division running vertically almost exactly through the centre of the organ. The two parts had retraced with a gap of fully two inches between them and the left half of the pancreas was lying entirely inferior to the base of the mesocolon and to the left of the rent in it. On the other hand, the right half of the pancreas was superior to the base of the mesocolon and difficult to examine through the rent, and, to expose it better, an incision was made in the greater omentum just distal to the stomach. By using these different methods of access, the two raw ends of the pancreas were approached and a few individual bleeding points were ligated. In view of the wide separation, there seemed little possibility of carrying out a successful end-to-end union, and it did not seem justifiable to prolong the operation by carrying out the alternative procedure of excision of the left half. The simple method was therefore adopted of inserting several deep mattress sutures into each severed end, which had the satisfactory effects of controlling hæmorrhage from the gland and of closing off most of the raw surfaces.

Even yet the total extent of the injury was not discovered, and the hæmorrhage continued, though now much more slowly. Using the approach through the greater omentum, a large vessel, posterior to the pancreas, was found completely severed, with one end lying quite free from its surroundings. This proved to be the splenic vein and its two ends were ligated. There was no damage to the splenic artery, aorta, or any other large vessel.

Five grammes of sterile sulphanilamide powder were applied at the site of injury. A large gauze pack was inserted through the opening in the greater omentum and was firmly placed between the ends of the pancreas, in order to control the slight oozing of blood which persisted and also to act as a drain for the anticipated collection of pancreatic secretion. The rent in the mesocolon was closed as far as possible, and the abdominal incision was firmly closed around the protruding end of the pack.

**POST-OPERATIVE COURSE.**—The patient stood the operation remarkably well, but nevertheless anxiety was felt on account of the possible formidable complications. The blood transfusion, started before operation and kept up during it, was continued

thereafter. A total of six pints of stored blood was thus administered during twelve hours and it was followed by two pints of plasma. The next day the patient was cheerful and in good condition. On the fourth day the gauze pack was removed, sodden with blood and pancreatic secretion, but no secondary hæmorrhage occurred. It was feared that complications might arise as a result of interference with the blood-supply to the transverse colon, but fortunately this proved unfounded.

**SUBSEQUENT PROGRESS.**—As was anticipated, a pancreatic fistula developed as a small opening at the site of drainage in the middle of the operation incision. The rest of the wound healed without difficulty and there was a complete absence of any sign of fat necrosis or wound digestion. During the next six weeks there were periodic bouts of upper abdominal pain, and there were several rises in temperature to 100° or over, lasting intermittently for a few days, settling down thereafter, but only to recur later. X-ray examination showed no sign of subphrenic abscess, pulmonary complication, or bony injury.

The type and quantity of the fluid passing from the fistula varied greatly, even from day to day. At times it was profuse, clear, and watery, and contained trypsin but none of the other pancreatic ferments and no bile-pigment. At other times it was thick and definitely purulent, and bacteriological examination showed a heavy infection with *Staph. aureus*, proteus, and *B. coli*. The fistula gradually became smaller and closed finally nine weeks after the operation. Interesting physiological observations on external pancreatic fistula were recently made by Comfort and Priestley (1943), but it was not possible to repeat them accurately on account of the very variable nature of the fluid and its heavy infection. It was noted, however, that the amount of discharge became definitely less on a low protein diet and increased again on an ordinary diet; it was not affected by a fatty or carbohydrate diet. It was not desirable to continue the low protein diet for too long, and it was tried experimentally on a few occasions for periods of three or four days.

At no time was there any obvious evidence of deficiency of the internal pancreatic secretion and glycosuria was never present. It was not considered necessary to carry out a blood-sugar curve. The faeces were examined at different times to investigate any deficiency of the external secretions. Two and a half weeks after the operation, the total fat in the dried faeces was 35 per cent, and four weeks after healing of the fistula it was 16 per cent, showing a possible mild degree of insufficiency at first. On both occasions the proportion of split fats to unsplit fats was 65 per cent to 35 per cent, indicating no loss in satisfactory fat digestion. The general condition remained quite good throughout and the appetite was seldom upset. In the nine weeks when the fistula was present, loss in weight was considerable, there being a fall to 7½ st. from a normal of over 10 st. On closure of the fistula, the weight became restored to normal in the next six weeks.

The only final disability was a small incisional hernia, for which a suitable belt was prescribed.

## DISCUSSION

**Varieties of Injury.**—An injury to the pancreas may naturally be produced by any variety of penetrating or perforating wound of the abdomen, for example by bullets, shrapnel, bayonet, or knife. This type is almost always

associated with severe injuries to other viscera and by its nature is often rapidly fatal. It forms a very small proportion of abdominal injuries treated by operation. The pancreas may rarely be damaged at surgical operations, particularly gastrectomy, nephrectomy, or splenectomy, and the diagnosis is to be suspected in the event of untoward complications after a particularly difficult technical procedure.

The subcutaneous type of injury is the most common and is as much a hazard of peace as of war. It is generally caused by some severe compression of the upper abdomen and the common mechanisms include crushing between two vehicles or beneath fallen masonry, running over by the wheel of a vehicle, and a kick or a blow on the unguarded abdominal wall. It is generally believed that the effect of any of these mechanisms is to push the pancreas violently against the rigid vertebral column, although Venable (1932) questioned this idea and put forward the theory of *contre-coup*, the pancreas being unable to transmit the wave force created by a blow through its substance. Various degrees of injury to the pancreas may be produced, such as simple bruising, a partial tear, or a complete tear, and it is possible for spontaneous resolution to follow the mildest traumata. In the rather more severe examples, several possible changes may take place, including acute pancreatitis with severe hæmorrhage or fat necrosis, a generalized peritoneal hæmorrhage, a localized hæmatoma in the lesser sac, acute peritonitis, or a pseudocyst, causing a swelling slowly increasing in size weeks or months later. Further reference to such injuries is omitted in this article.

The most severe injury is a complete division of the pancreas through the middle, the pancreatic duct escaping only in very rare instances. The pancreatic injury tends to be associated with and overshadowed by damage to other structures such as stomach, duodenum, duodeno-jejunal flexure, jejunum, liver, kidney, spleen, transverse mesocolon, and large blood-vessels, especially the splenic vein. These multiple injuries must necessarily be very severe, and it is highly probable that many of the cases are never diagnosed but die almost at once or within a few hours. In those patients who survive the immediate injury, there are no typical signs suggestive of pancreatic trauma, and the manifestations are those of any serious abdominal injury associated with severe hæmorrhage. The estimation of the urinary diastase is probably the only useful laboratory test, a high reading being indicative of a pancreatic lesion.

**Previous Examples of Complete Rupture.**—The literature on the subject of pancreatic trauma reveals very few instances of total severance of the organ, although there are more references to the less complete cases. What is generally believed to be the first recorded example was that of Travers in 1827, quoted by Moynihan (1926) among others: Following a

run-over accident, autopsy demonstrated a pancreas torn completely across, in association with ruptures of the duodenum, jejunum, and transverse mesocolon, and with many fractured ribs. Mayo Robson and Cammidge (1907) referred to the fatal case of Wilks and Moxon, the pancreas being divided into two parts, and they also reproduced the illustration of a similar specimen in St. Bartholomew's Hospital Museum. Cases of total division of the pancreas, with successful results after operation, were those of Garré in 1905 (quoted by Moynihan), Feist in 1926 (quoted by Bailey, 1944), Newton (1929), and Brown and Barlow (1932), who also quoted the case of Heineke in 1907. It is not advisable to attempt any accurate enumeration of such cases, as several references have not been traced and other references do not indicate clearly the exact extent of the injury.

**Treatment.**—The correct treatment in all pancreatic injuries is undoubtedly operation, and figures as long ago as those of Mikulicz (1903) show the advantages over non-intervention. In complete division of the pancreas, owing to the severe hæmorrhage present, operation must necessarily be performed early, and Garré, Brown and Barlow, and I myself operated about six hours after the injury and Newton a little over twenty-four hours after. The actual management of the tear in the pancreas varies according to the operator's own views and to the local findings, and success has followed different methods. Drainage either by a gauze pack or by a rubber tube seems essential, either along with methods of suture or possibly as the only method in desperate cases or those with much friability of the pancreas. Newton was able to carry out a direct end-to-end suture of the two portions of the pancreas, the two ends of the duct being merely approximated, not united, and an omental flap being used to encircle the suture line. Garré and Brown and Barlow also performed direct sutures. Walton (1930) had previously indicated that such a method was bound to fail, and suggested the complete removal of the separated body and tail and careful suture of the divided stump of the neck. In my own case, the two ends of the pancreas were so widely separated that end-to-end union was impossible, and the easiest method was therefore to close the two raw ends separately by sutures. After direct end-to-end suture, it seems doubtful if the left half of the pancreas can ever recover its full external secretory functions, as the chance of the duct regaining its normal patency seems remote. However, there does not appear to be an obvious loss of any of the pancreatic functions after the various operations.

The external pancreatic fistula, which is an almost constant sequel, usually closes spontaneously after several weeks or months, but during that time there is a considerable loss in weight. It may give rise to very painful digestion of the wound, and Fast (1930) used a method

recommended by Potter (1927) for duodenal fistula, which, it is maintained, allows rapid relief from this complication and early closure of the fistula. A catheter is held in the fistula and packed around with gauze soaked in 10 per cent solution of Witte's peptone; through the catheter hydrochloric acid  $N/10$  is instilled into the fistula at the rate of 20 minims per hour. A high caloric diet is given and it is claimed that digestion of the wound ceases in twenty-four hours, although the fistula may not heal for thirty days. In my own case, with an absence of wound digestion and the presence of an intermittent purulent discharge, there was no indication for using this method.

## SUMMARY

A report has been given of a young adult male who received a momentary severe crushing of the upper abdomen. At operation, six hours after the accident, a gross degree of intraperitoneal hæmorrhage was present, and there existed a complete division of the pancreas into two parts, with wide separation. The two raw ends were separately closed by sutures, and a large gauze pack was inserted for drainage and hæmostasis. Other injuries were a transection of the splenic vein and tears of the transverse mesocolon and the lesser omentum. An external pancreatic fistula was a sequel, closing spontaneously in nine weeks, and the final result was excellent.

Mention has also been made of 8 previously reported cases of complete rupture of the pancreas, with successful results in 5 cases after operation. Methods of management of the pancreatic injury have been discussed.

I wish to express my thanks to Mr. A. Philp Mitchell, Surgeon, Leith Hospital, for the opportunity of operating on this most interesting abdominal injury, and for much guidance and encouragement in writing this article.

## REFERENCES

- BAILEY, H. (1944), *Emergency Surgery*, 5th ed., 217. Bristol: John Wright & Sons.  
 BROWN, O. H., and BARLOW, L. C. (1932), *J. Amer. med. Ass.*, **98**, 1882.  
 COMFORT, M. W., and PRIESTLEY, J. T. (1943), *Proc. Mayo Clin.*, **18**, 409.  
 FAST, W. K. (1930), *J. Amer. med. Ass.*, **95**, 1668.  
 MAYO ROBSON, SIR A. W., and CAMMIDGE, P. J. (1907), *The Pancreas; Its Surgery and Pathology*, 345. London and Philadelphia: W. B. Saunders Co.  
 MIKULICZ, VON (1903), *Ann. Surg.*, **38**, 1.  
 MOYNIHAN, LORD (1926), *Abdominal Operations*, 4th ed., 2, 446. London and Philadelphia: W. B. Saunders Co.  
 NEWTON, SIR ALAN (1929), *Surg. Gynec. Obstet.*, **48**, 808.  
 POTTER, C. (1927), *J. Amer. med. Ass.*, **88**, 899.  
 VENABLE, C. S. (1932), *Surg. Gynec. Obstet.*, **55**, 652.  
 WALTON, SIR A. J. (1930), *The Surgical Dyspepsias*, 2nd ed., 578 and 606. London: E. Arnold & Co.

# ISCHÆMIC DAMAGE IN THE PERIPHERAL STUMP OF A DIVIDED NERVE

BY H. J. SEDDON AND W. HOLMES\*

DEPARTMENT OF ORTHOPÆDIC SURGERY AND DEPARTMENT OF ZOOLOGY, OXFORD

It has been shown by Holmes, Highet, and Seddon (1944) that the nerve lesions found in Volkmann's ischæmic paralysis, apart from those directly due to the injury that produced the vascular damage, are the result of an ischæmia of the nerves, which is most severe where they traverse the zone in which the ischæmia of muscle is maximal. The damaged nerve remains, of course, in continuity, but a gross interference with its normal blood-supply may cause irreparable intraneural change, in the form of an obliterative collagenization within the nerve-bundles themselves.

In the case about to be described the ischæmic damage was confined to the peripheral stump of a divided nerve, the neighbouring muscles being apparently unaffected. This finding was an accidental one, but its significance may well be considerable; the case has, therefore, an interest not determined solely by its rarity.

## CASE REPORT

**HISTORY.**—On March 9, 1942, a Royal Air Force pilot (born in 1916) crashed over enemy-occupied territory and suffered a compound fracture of the upper third of the left radius and ulna, with damage to the median and ulnar nerves. He seems to have been fairly well treated, though the first plaster was too tight and produced two deep sores at the wrist. After 4–5 weeks there was some return of sensation and movement in the fourth and fifth digits.

*November, 1942:* Wound healed.

*July, 1943:* Excision of head of radius, with incidental damage to the posterior interosseous and superficial radial nerves. The operation was done with a view to restoring pronation and supination.

*Oct. 26:* Repatriated.

*Dec. 16:* Sent by the Royal Air Force to the Wingfield-Morris Hospital for consultation.

**ON EXAMINATION.**—The wound in the upper third of the forearm lay anterolaterally and there was much deep scarring. The head of the radius had been excised, and the fracture of the upper third of its shaft had united. The ulnar fracture was ununited and there was severe lateral bowing with anterior displacement of the distal fragment.

*Median nerve:* Paralysis was complete except for a flicker (? trick movement) in flexor pollicis longus and in one or other of the long flexors of the middle finger; there was a typical zone of sensory loss and anhidrosis.

*Ulnar nerve:* Flexor carpi ulnaris 4 (Medical Research Council, 1942, grading): flexor digitorum profundus 3 to 4th digit and 4 to 5th: all intrinsic muscles paralysed except adductor pollicis and the first dorsal interosseus. Normal sensibility; hypohidrosis in the palmar distribution of the nerve. Electrical reactions and electromyography confirmed the diagnosis of a partial lesion of the ulnar nerve.

There was some derangement of *radial* nerve function, but there seemed to be no doubt that recovery was well advanced.

*Contractures:* Slight flexor contracture of all digits, but no more than is commonly seen after nerve injuries in the forearm.

*Blood-vessels:* Radial pulse not palpable, ulnar pulse normal.

*The diagnosis* seemed clear enough. The median nerve was almost certainly divided at the level of the wound; the radial artery had been damaged at the

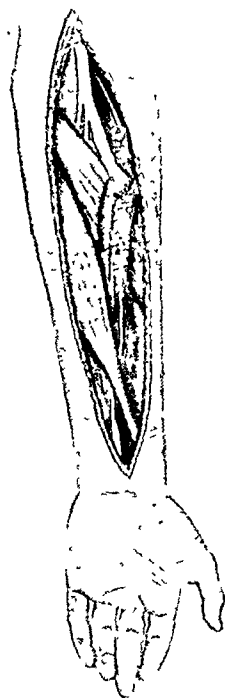


FIG. 319.—The state of affairs at operation. For the sake of clarity the deformity of the forearm is not shown, nor is the scarring properly represented—it was such that pronator teres and flexor carpi radialis were with difficulty recognizable proximally. For description see text.

same level; there was, presumably, a partial division of the ulnar nerve at the site of fracture; and the state of the bones was obvious. There was no suggestion whatever of an ischæmic lesion, and the case was not investigated from this standpoint. The plan of attack on this severely damaged forearm was, however, the subject of some debate; it was finally decided to deal with the non-union of the ulna and with the median nerve lesion at the same session. There was no indication for exploring the ulnar, since the activity of adductor pollicis and the first dorsal interosseus gave promise of spontaneous recovery in the other ulnar intrinsic muscles.

\* Beit Memorial Research Fellow.

**OPERATION (Feb. 2, 1944).**—The fracture of the ulna was first exposed, then the divided median nerve. The latter ended in a large neuroma (Fig. 319) at a point 9 cm. below the medial epicondyle. The peripheral stump, however, could not be identified until the incision had been carried down to the level of the wrist. Here the nerve was only 4 mm.  $\times$  2 mm. in diameter, was purplish-grey in colour, and its bundles were only just visible. On tracing it upwards it was found to become even smaller, diameter 2.5 mm.  $\times$  1.5 mm., dirty grey in colour, soft

shown no activity clinically as late as twenty-three months after the injury.

Thus when the operation was concluded there was no more than a hazy notion in our minds that this curious shrinkage of the peripheral stump was the result of ischaemia.

**HISTOLOGICAL EXAMINATION OF THE PERIPHERAL STUMP.**—At the distal end of the specimen the general arrangement of the nerve-bundles was normal (Fig. 320). But in internal structure they were greatly changed, for there had been a massive increase of collagen in the endoneurium, leading in most areas to complete obliteration of the Schwann tubes (Fig. 322), in some to a great restriction of their lumina. The collagen in the bundles was composed of dense, deeply-staining strands; consequently there was a marked difference even at low power of magnification between this nerve and one which has undergone Wallerian degeneration (Fig. 320; cf. Fig. 321, which is a similarly stained transverse section

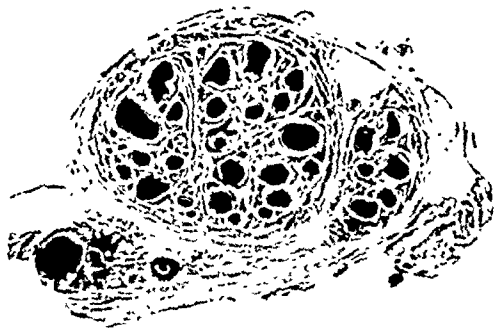


FIG. 320.—A transverse section of the specimen of the distal stump of the median nerve. Masson. ( $\times$  12.) The bundles are filled with deeply-staining collagen.

and apparently avascular. This minute thread was lost above in the much damaged forearm muscles. The resemblance to an ischaemic nerve lesion was recorded at the time, though with some hesitation since the neighbouring muscles showed no change apart from those attributable to past sepsis and denervation. The anterior interosseous artery was

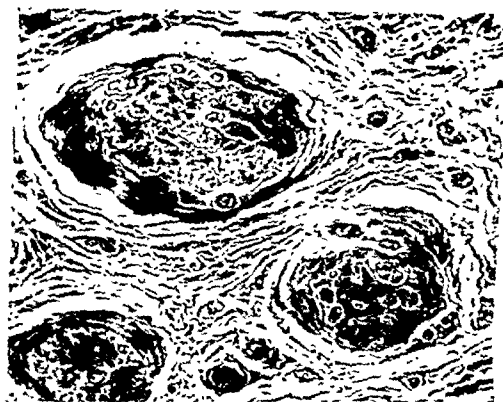


FIG. 322.—Detail from part of the section shown in Fig. 320. Masson. Scale = 100 $\mu$ . The collagenization and hypervascularization of the bundles can be seen.



FIG. 321.—A specimen of the distal trunk of the median nerve from another case in which the nerve had been completely divided, and had undergone Wallerian degeneration only. Compare with Fig. 320; the two sections were stained and photographed together. ( $\times$  12.)

nowhere to be seen. Since repair of the nerve was entirely out of the question, a length of the thread-like peripheral stump was removed for examination. It is regrettable that no muscle was removed, but it did not then occur to us that there was any reason for examining muscle, especially as electrical stimulation of the central stump produced contraction in pronator teres, flexor carpi radialis, and the long flexors of the fingers, presumably flexor sublimis digitorum. The branches to these muscles were, of course, derived from the central stump; they had evidently been severely damaged in continuity, for they had

of the distal trunk of a nerve that had undergone Wallerian degeneration only). Very few Schwann cells could be identified in the bundles, even in those tubes which had not been completely obliterated: at all points in the nerve there was an abnormally large number of small blood-vessels.

At the proximal end of the specimen, where the shrinkage of the nerve was considerable, the internal structure of the bundles was similar to that seen at the distal end, though they were all of smaller diameter, indicating that the shrinkage of the whole trunk was partly due to shrinkage of the individual bundles: the amount of epineurial connective tissue was not significantly different at the two ends. There were also fewer bundles in the proximal than in the distal section, indicating that the shrinkage was also the result of an actual replacement and removal of nerve tissue.

## DISCUSSION

Comparison of this specimen with those previously examined (Holmes et al., 1944) showed beyond all reasonable doubt that the state of the peripheral stump was due to ischaemia; the extreme shrinkage of the nerve as a whole and the obliteration of the Schwann tubes by dense collagen is found, so far as we know, only in

nerves damaged by severe ischæmia. The curious feature of the case was the absence of other evidence of ischæmic damage. It must be admitted that the exclusion of ischæmic changes in muscle is much more difficult than the demonstration of their presence, but it may be said with confidence that had such extreme nerve damage been the result of a regional ischæmia the muscle changes would have been unmistakable to even the most casual observer.

One must, therefore, look for vascular damage having a selective action on the median nerve: there is no need to look very far. The median nerve in the forearm derives its main blood-supply from the anterior interosseous artery, and from a few collateral branches. In any nerve occlusion of the collateral branches is harmless (Adams, 1942, 1943) provided that the longitudinal supply is intact, but interference with the main longitudinal anastomoses is definitely harmful (Durward, 1944). In one case described by Holmes and his colleagues—the last in their series—the only demonstrable arterial lesion in a case of ischæmic paralysis of the forearm, with involvement of the median nerve, was occlusion of the distal part of the anterior interosseous artery. But the nerve lesion was a mild one, and almost complete recovery occurred. The nerve was in continuity and there was, therefore, some opportunity for maintenance of the circulation from above. Here, on the contrary, the nerve had been completely severed high in the forearm and thus the distal stump was completely deprived of its proximal blood-supply. The collateral circulation must have been inadequate

too, since the radial artery was destroyed in the proximal third of the forearm. This suggests the important conclusion that in mobilization of the distal stump of a median nerve for the repair of a lesion in the upper third of the forearm the anterior interosseous artery should be treated with respect, for it may be the chief source of nourishment of the nerve: perhaps neglect of this precaution accounts for some of the failures after suture at this level, when conditions were not at all adverse in other respects.

### SUMMARY

1. A case is described of division of the median nerve in the upper third of the forearm with severe ischæmic damage of the peripheral stump. There was, apparently, no concomitant ischæmia of muscle.

2. The anterior interosseous artery was destroyed, and it is suggested that this, together with the division of the nerve, cut off the main longitudinal blood-supply of the nerve.

3. In the performance of operations on the forearm for repair of proximal division of the median nerve, it is probably wise to avoid disturbance of the anterior interosseous artery.

### REFERENCES

- ADAMS, W. E. (1942), *J. Anat.*, **76**, 323.  
 — (1943), *Ibid.*, **77**, 243.  
 DURWARD, A. (1944), unpublished work.  
 HOLMES, W., HIGHT, W. B., and SEDDON, H. J. (1944), *Brit. J. Surg.*, **32**, 259.  
 MEDICAL RESEARCH COUNCIL (1942), *War\* Memorandum No. 7*, H.M. Stationery Office.

## A CASE OF TRAUMATIC DIAPHRAGMATIC HERNIA

BY HUGH REID

HONORARY SURGEON, ROYAL INFIRMARY, LIVERPOOL

TRAUMATIC hernia may be caused by a direct injury to the diaphragm, such as by a knife passing through the ribs and wounding the diaphragm, by necrosis produced by pressure from a drainage tube of an empyema lying on its upper surface, or it may arise from rupture of a subphrenic abscess into the thoracic cavity. On the other hand the condition may be brought about by indirect violence, as by a crushing accident which ruptures the diaphragm and allows the stomach, the intestines, or the spleen to enter the thoracic cavity. Such herniæ have no sac and might therefore more accurately be described as false herniæ or eviscerations. The case here reported belongs to this latter type.

### CASE REPORT

CLINICAL HISTORY.—The patient, A. D., a coal miner aged 53, was admitted to the Royal Infirmary in Jan. 27, 1943. He gave a history that three years

previously he was crushed by a fall of coal while working in a mine. He was treated in Chirk hospital for twenty-four weeks for fractured femur and fractured upper lumbar spine. After this he recovered completely and went back to work.

In January, 1930, he was knocked down by a horse and was hospitalized for six weeks suffering from a crushed foot. There was no sign or symptom of chest or stomach trouble after either of these accidents.

A third accident occurred in November, 1941, when he was knocked down by a waggon and hurt his ribs and back. Since then he had pain in his left chest, constant in nature, which kept him awake at night so that he had to sit up in bed and was hardly free from pain for longer than half an hour.

About two months before his admission to the Royal Infirmary he began to vomit irregularly, without relation to the taking of food, and on Jan. 19, 1943, he vomited some blood.

A preliminary X-ray examination of the stomach, by Dr. Charles Salt, of Chirk, showed that barium

after passing down the œsophagus went upwards into the thoracic cavity as far as the left clavicle. He was then referred to the Royal Infirmary.

Three stay sutures of No. 2 chromic catgut were then inserted in the anterior lip of the rent and three in the posterior lip, and by traction on these sutures



Fig. 323.—Before operation, showing position of stomach in chest. Patient lying on face.



Fig. 324.—Before operation, showing position of stomach in chest. Patient lying on back.

#### X-RAY EXAMINATION (Dr. R. E. Roberts).—

Feb. 2.—The stomach is seen to occupy a position in the left thorax, its shape being roughly that of a horseshoe with concavity downwards. The cardiac orifice is at the level of the 11th intercostal space, near the middle line, whilst the pylorus lies in the 10th interspace a few inches to the outer side of the cardiac orifice. The body and pyloric antrum, corresponding to the curved portion of the horseshoe, rises into the thorax as high as the 4th rib posteriorly, or the 2nd intercostal space anteriorly. (Figs. 323-325.)

The outline of the left diaphragm cannot be made out. The region around the pyloric antrum shows a homogeneous semi-opacity containing a few gas translucencies; the splenic flexure is seen lying to the left side of the stomach, and rising into the thorax as high as the 5th rib in the axillary line.

OPERATION (Feb. 12).—The patient was placed on the operating table on his side, with the left side uppermost. A long incision was made in the chest through the 7th intercostal space and the pleural cavity opened. Rib spreaders were then inserted to keep the ribs apart. The left lung was found to be collapsed and compressed by abdominal contents, which had passed up into the thoracic cavity through a very large rent in the diaphragm. The whole of the stomach was in the chest, being attached below by the œsophagus at the œsophageal hiatus and forming from this point a horseshoe-shaped loop upwards towards the clavicle and downwards to the level of the 7th rib where it joined the dislocated duodenum. The whole of the spleen and the splenic flexure of the colon had also passed through the rent.

No adhesions were present, but it was with some difficulty that the stomach and spleen and colon were gradually reduced into the abdominal cavity. A search was then made for the edges of the rent, which were found to be widely separated.

an attempt was made to draw the edges together. This could only be effected after first crushing the phrenic nerve with a hæmostat as it lay on the



Fig. 325.—Before operation inverted stomach. The fluid level is in the Patient erect

pericardium so as to paralyse and relax the diaphragm, and by resecting about an inch of the anterior and posterior ends of the 7th and 8th ribs so as to allow the chest wall to fall in towards the middle line and so narrow the opening. With the aid of these manoeuvres the stay sutures could be approximated.

With a long pair of scissors the edges of the rent were freshened by separating the pleura on their upper surfaces from the peritoneum on their under surfaces. These two membranes had united with each other to form a smooth lining covering the edges so that no muscular or membranous fibres were visible until the freshening process had been completed. Further interrupted strong (No. 2 chromic) catgut sutures were then inserted between the stay sutures as they held the edges of the rent together, and the remains of the diaphragm were thus sutured together so as to obliterate the rent and reconstruct the diaphragm without undue tension. The sutures were passed on a curved needle from the pleural surface through the fibres of the diaphragm into the peritoneal surface, then from the peritoneal surface of the opposite side through the diaphragm to the pleural surface, and the knot tied on the pleural aspect. It was felt that further reinforcement of the suture line was advisable in case the sutures gave way. Two long strips of fascia lata were therefore excised from the left thigh. These strips were

sewing up the intercostal muscles and the muscles of the chest wall. No drainage was used because it was considered that any effusion which might



Fig. 326.—March 3, thirty-two days after operation, showing stomach in normal position in the abdomen. Patient erect

interlaced by means of a Gallie needle along the upper surface of the suture line like bootlaces, passing from the mesial end of the suture line near the œsophageal opening to the lateral end at its junction with the chest wall.

The original incision in the chest wall was then closed by approximating the 7th and 8th ribs and



Fig. 327.—Thirty-two days after operation. Lung expanded, fluid disappeared. Patient erect.

subsequently arise could effectively be dealt with by aspiration.

Anæsthesia was carried out by G. O. E., using an intratracheal closed circuit method (Dr. Halton).

The whole operation took one and a half hours. The patient was given a continuous transfusion of blood and left the table in good condition.

PROGRESS.—On Feb. 17 the chest was explored by a needle and 32 oz. of serous fluid were removed from the pleural cavity. Further aspiration was done on Feb. 19 and on Feb. 23, when small amounts of fluid were withdrawn.

On Feb. 25 *X-ray examination* showed no fluid in the chest and the lung was expanding satisfactorily. The patient felt quite comfortable and was able to leave his bed.

March 3.—The stomach is now seen to be completely reduced into the abdomen. Its cardiac end is at the level of the 11th rib posteriorly, being surmounted by a well-defined diaphragm (Fig. 326). The pylorus is now at the level of the 2nd lumbar vertebra. The stomach now presents a normal J-shape. The splenic flexure is also in its normal position.

Subsequent *X-ray examination* showed that the left lung had expanded, and that the residual pleural space and the fluid had disappeared, the bony cage of the left thorax showing a slight falling in. The heart was not appreciably displaced (Fig. 327).

Subsequent progress has been uneventful and he is now at work.



## AN OPERATION FOR REMOVAL OF CARCINOMA OF THE ŒSOPHAGUS WITH PRESTERNAL ŒSOPHAGO-GASTROSTOMY

By HERMON TAYLOR

ASSISTANT SURGEON, LONDON HOSPITAL; SURGEON, F.M.S.  
SURGEON, KING GEORGE HOSPITAL.

THE treatment of carcinoma of the œsophagus varies according to the situation of the lesion. For the more superficial tumours at the upper end, radiotherapy has become the method of choice, but within the chest it is apparently not possible to destroy a growth completely by this means, without causing fatal damage to the vital tissues of the heart and lungs. Fortunately, the risk of surgical removal of the intrathoracic part of the œsophagus has latterly been very greatly reduced by new methods of anaesthesia and by measures to combat operative shock and post-operative infection. Although the main difficulties of transthoracic œsophagectomy have been largely overcome, however, the restoration of natural swallowing afterwards has only been satisfactorily achieved in the case of growths of the lower part of the organ. Here the tumour can be removed and the stomach mobilized through the diaphragm into the chest to obtain a direct gastro-œsophageal anastomosis in the manner first described by Sauerbruch. This operation has now become almost standardized, and Garlock has recently shown that it can be made to include growths which extend as high as the concavity of the aortic arch by bringing the œsophagus to the left of this structure.

The anastomosis is a precarious one by intestinal standards because of the friable nature and longitudinal direction of the fibres of the bare outer muscular coat of the œsophagus, but by telescoping the cut end into the peritoneal surface of the fundus of the stomach, and by anchoring the stomach to the pleura to relieve the tension on the suture line, a tolerably safe union can be obtained. There is, however, a limit to which this can be done and no comparable way of restoring deglutition after mid-upper œsophageal resection has yet been described. At present the only alternative to Torek's original plan of establishing permanent cervical and epigastric fistulæ is the construction of a skin-tube between them. This is an unsatisfactory position because the fashioning of such a tube requires a number of plastic operations extending over a long period of time after the main operation, and the patient may even develop metastases before the process is complete. Moreover, skin does not tolerate gastric juice well, and many attempts to construct skin tubes have ended in failure. On the other hand, the fistulæ themselves are very troublesome and sore, and it is questionable whether a patient is greatly benefited by the successful removal of his growth unless he is able to swallow his food and saliva fairly soon afterwards.

The same problem of how to close the gap in the alimentary canal arises in the case of a cardiac growth which involves so much of the stomach wall that an endothoracic anastomosis cannot be performed without inadequate removal of tissue. The question in both cases is how to get the stomach to come up to meet the œsophagus, and it is therefore significant that as the patient lies propped up in bed with flexed neck and trunk, the shortest distance between the cricoid and the duodenum lies in the plane of the sternum. For this reason the stomach can be mobilized higher in front of the sternum than round the curve of the posterior mediastinum behind the heart. In this paper an operation is therefore suggested in which an œsophageal or gastro-œsophageal resection of a growth is followed by a presternal or suprasternal anastomosis between the stump of the œsophagus and the stomach or the remaining part of it (Fig. 328).

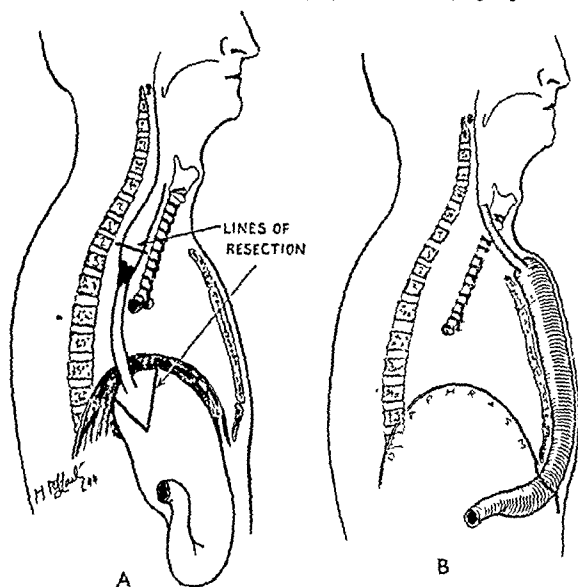


FIG. 328.—Diagrammatic representation of the operation. A Shows the gastro-œsophageal resection; B, Shows the remainder of the stomach brought upwards to the front of the sternum and anastomosed to the stump of the œsophagus.

Such a procedure is, of course, a formidable undertaking, but this is a consideration which must be viewed against the hopeless and distressing alternative for a patient with a growth of the œsophagus or cardia.

The operation has been put into practice in three cases, with one death from accidental pneumothorax of the opposite side of the chest,

one death from empyema after eight months, and one patient alive, taking soft food by mouth and enjoying her life at home eighteen months later. The following is a description of the operation as I have performed it, with such modifications as experience has suggested.

### TECHNIQUE

Pre-operative preparation consists in rest in bed for two to four weeks with a high caloric fluid diet by mouth, unless obstruction is absolute. This period is used to remove all septic foci in the mouth, to reduce œsophageal stasis by regular lavage with an œsophageal tube, and to give a blood transfusion if required. Œsophagoscopy is essential to confirm the diagnosis by inspection and biopsy. It may also provide evidence of fixity of the gullet in the mediastinum or, with bronchoscopy, involvement of the trachea or left bronchus, which would, of course, contraindicate operation. At the same time it affords an opportunity of dilating the stricture if necessary, to facilitate feeding and œsophageal drainage. Shortly before operation a course of local chemotherapy is instituted in which the lavage after each feed is followed by a dose of sulphathiazol suspension in order to reduce the infection of the growth. Breathing exercises are instituted and the patient is familiarized with the oxygen mask in preparation for the post-operative period. Preliminary jejunostomy is not necessary if there has been a good response to these measures, but may be required if the œsophageal obstruction has not sufficiently diminished under treatment.

Cyclopropane and oxygen administered by cuffed endotracheal tube is the method of anaesthesia adopted, in order to give the anaesthetist unhampered control of respiration by means of positive pressure when the chest is open and the physiological mechanism for expanding the lung cannot function. The operation commences with the setting up of a drip transfusion of blood, followed later by plasma, and in anticipation of a lengthy dissection measures to keep the patient warm are taken from the outset, and pulse-rate and blood-pressure readings are taken at 15-minute intervals.

The procedure for a growth in the upper half or two-thirds of the œsophagus will first be described. For this, a right thoracotomy is chosen in order that the dissection in the region of the aortic arch may proceed more readily under vision. The patient is therefore placed in a half-left lateral position and his right arm is supported by an assistant, as it will be required to be moved during the operation. The right pleural cavity is opened through the bed of the 6th rib and any parietal adhesions of the lung are separated until it lies on the mediastinum and the growth in the œsophagus is exposed. If there is no obvious infiltration of the mediastinum the pleural covering is incised, the azygos vein is divided, and the growth is gently dissected free, care being taken to avoid tearing the left pleura

below. Even with positive pressure in the trachea such a tear may have a valvular action, and if it occurs there is danger of a contralateral pneumothorax, with obstruction of the pulmonary blood-flow, and general circulatory failure (*see Case 3*). The opening should therefore be carefully sutured, but if this is not possible a vent tube should be put through it until the end of the operation, to prevent any possibility of valve action and to allow the anaesthetist to keep the lung fully expanded.

While the mediastinal dissection is proceeding, in fact, as soon as it has been decided that the condition is operable, an independent assistant makes two other short incisions. The first, about 1½ in. long, is made into the peritoneal cavity through the midline of the epigastrium and the wound is covered with a towel until it is required. The second incision, about 1 in. long, is made transversely in the skin over the supra-sternal notch. Through this opening the assistant tunnels downwards in the relatively bloodless subcutaneous tissue in front of the sternum, by the method of repeated scissor-spreading, as far as the length of the scissors will allow. This tunnel will eventually accommodate the upper stump of the œsophagus, and if it is prepared in advance in this way much time will be saved in the later manœuvre.

Meanwhile, within the chest, the surgeon completes the mobilization of the whole length of the œsophagus by freeing the two ends. Below, the attachments of the cardia are separated from the œsophageal hiatus of the diaphragm, the peritoneal cavity being deliberately opened anteriorly. Above, the loose cellular tissue at the root of the neck strips easily from the œsophagus until the cricoid is reached. Great gentleness is required here to avoid damage to the important descending œsophageal branches of the inferior thyroid arteries. When the œsophagus is quite free from the cricoid to the stomach, a special long curved clamp is introduced into the epigastric incision and, passing between the stomach and the left lobe of the liver, is guided by the surgeon's fingers through the peritoneal opening which was made at the œsophageal hiatus of the diaphragm, and continuing high into the chest is clamped across the œsophagus above the growth. The first two fingers of the surgeon's left hand now slide up the œsophagus to the cricoid, and work their way forward in the neck between the pharynx and the right carotid sheath until they present at the assistant's suprasternal incision which is also the mouth of the subcutaneous tunnel. This manœuvre is illustrated in the diagram for greater clarity (*Fig. 329*). The fingers guide the blades of a second clamp from the cervical incision down into the chest, where they are applied to the œsophagus immediately above the first clamp. The œsophagus is then divided between the clamps, which are immediately withdrawn to the exterior, carrying the two parts of the œsophagus with them.

The lower part is carried through the diaphragm and out of the epigastric incision; the upper part is drawn through the root of the neck to the space

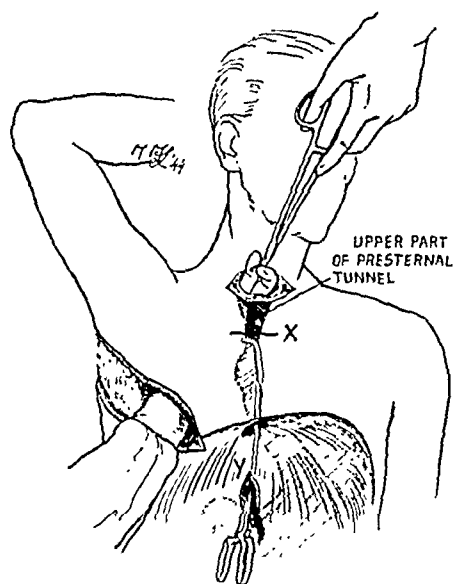


Fig. 329.—The surgeon's fingers protruding from the suprasternal incision (see text).

of Burns, whence it is thrust down the presternal tunnel as far as it will go. The assistant completes the cervical part of the operation by bringing the end of the upper part of the œsophagus out through a short counter-incision over the tunnel, after which the suprasternal incision, having served its purpose, is sutured. The edges of the œsophageal opening in the diaphragm may be approximated if necessary, after which the mediastinum is dusted with sulphonamide powder and the thorax is closed with under-water drainage. Dressings are applied, the lung is expanded by the anæsthetist, and the patient is slowly placed on his back.

The first stage of the operation having now been completed, the general condition of the patient is critically reviewed by the surgeon and the anæsthetist, to decide whether it is possible to proceed at once to the mobilization of the stomach into the presternal position. If the anæsthetist's chart indicates a progressive fall of blood-pressure, especially if the systolic reading is below 100 mm. of mercury, the second stage should be postponed until a later date. In case of doubt, the patient's response to an interval of ten-minutes' rest is a useful indication of the degree of reserve vitality he possesses.

If it is considered wiser to desist, the upper end of the œsophagus is sutured to the opening in the presternal tunnel, the growth is removed from the lower œsophagus and this end is sutured to the skin of the epigastrium. In the interval before the second stage the patient will be fed through the lower œsophagostomy and later the

two fistulæ may be temporarily connected by an external tube, as in Torek's case.

The second stage, can, however, be fairly rapidly performed and it is very desirable to avoid the epigastric fistula if possible. If therefore, it is decided to proceed at once to the anastomosis, the epigastric incision is enlarged and the presternal subcutaneous tunnel is extended downwards to join it. The stomach is now mobilized by gentle traction on the œsophagus which facilitates the division of the root of the coronary vessels beyond the glands in this region, as well as the vasa brevia to the spleen, and the great omentum along the greater curve. This can be done without visible impairment of the blood-supply of the fundus of the stomach, if care has been taken to avoid damage to the pyloric and right gastric-epiploic vessels. It will now be found that the stomach can be withdrawn entirely from the abdomen and laid on the front of the chest with the fundus as high as the sternal angle of Ludwig. By mobilizing the duodenum as well, it can be drawn even higher so that the pylorus lies over the xiphisternum and the fundus reaches above the clavicle. This degree of mobilization is only necessary after a very high resection of the œsophagus, but enough of the stomach is freed to allow the fundus to reach the upper end of the œsophagus without tension. The growth, with the lower œsophagus, the cardia, the upper part of the lesser curve, and the glands which have been dissected up from the coeliac axis are now removed and the opening in the stomach is closed in two layers. The fundus is drawn up the presternal tunnel to the counter incision for the anastomosis, while the assistant closes the epigastric wound, taking care to leave plenty of room for the stomach to pass between the muscles without constriction. The fundus is sutured to the chest wall about 1 in. higher than the upper end of the œsophagus, which is laid on its surface and sutured in position. A small incision is now made into the stomach wall opposite the end of the œsophagus and an anastomosis is made between the two openings, the suture line being covered by drawing the anterior wall of stomach up over it. The skin over the anastomosis is closed with drainage of the subcutaneous tissue and the operation is completed by passing a small nasal tube through the anastomosis into the presternal part of the stomach.

When the operation is performed for growths of the lower part of the œsophagus or of the cardiac end of the stomach, the exposure is through the bed of the seventh left rib, the diaphragm is incised radially from the œsophageal hiatus, and the growth is dissected free. The first steps are therefore those of Sauerbruch's operation, which will be the method of choice if the growth is limited to the cardia or does not extend higher than the concavity of the aortic arch. The surgeon may well defer the selection of an intra- or an extra-thoracic anastomosis,

until, with the parts in his hands, he is in a position to assess the practicability of the former. If this is not possible he need not abandon the resection, but may proceed to apply the principle of the operation described above with sufficient modification to conform to the anatomy of the aortic arch. Thus the œsophagus must be freed by blunt dissection with the finger between the deep side of the arch and the azygos vein after infiltrating this region with  $\frac{1}{2}$  per cent novocain; the dissection of the root of the neck is to the left of the trachea, and in passing the œsophageal clamp down from the neck into the chest it must follow the same path between azygos vein and aortic arch before being applied to the lower œsophagus and withdrawn. The blood-supply of the œsophagus is more precarious when it is divided low down, and particular care must be taken in dissecting the root of the neck not to damage the vessels joining the upper end from the inferior thyroid trunks. It is expedient also to extend the incision across the costal margin and left rectus muscle to the epigastrium to obtain a wide thoracico-abdominal exposure for the dissection of an extensive growth in the stomach. The spleen and proximal omentum should be removed with the growth and the stomach divided about half-way down the greater curvature and as far as the incisura on the lesser curve. *Case 3* shows that this degree of removal of tissue is still compatible with a presternal anastomosis if the duodenum is mobilized as well as the stomach. Apart from the approach and exposure, and the dissection below the diaphragm and opposite the aortic arch, the execution of the operation follows the same lines as that described for upper œsophageal resection.

During the post-operative period the patient is sustained by fluid diet by the nasal tube, through which sulphathiazol suspension is also administered. When not used for this purpose the tube is kept open to the atmosphere to prevent gas distension of the stomach and thus remove any internal strain on the anastomosis. Leakage here is fraught with danger of widespread infection of the subcutaneous tissue in front of the chest and a careful watch must be kept to prevent this. The integrity of the suture line may be tested by a drink of methylene blue which will ooze from the local drainage tubes if it is not sound. Continuous suction to remove escaped saliva may prevent a complete breakdown, but if inflammation is spreading it is better to limit this by opening up the wound and intubating the fistula.

If the anastomosis holds, nothing is allowed by mouth until the œsophagus and stomach are firmly adherent in their new position, but mouth-washes may be freely used. Sips of fluid may be given on the seventh day and the nasal tube is removed on the tenth day if all is well. The under-water drain is removed when the discharge has ceased to be copious, but the residual pleural fluid is aspirated at intervals and cultured, and

penicillin may be injected at the same time to minimize the risk of secondary infection from the bronchopneumonic lung.

## CASE REPORTS

*Case 1.*—The patient was a man of 61 with chronic bronchitis, an emphysematous chest, and a squamous carcinoma  $2\frac{1}{2}$  in. long in the middle of the œsophagus. With Mr. C. B. Lewis administering the anæsthetic, the operation was performed on July 24, 1942, through a right thoracotomy incision. Widespread adhesions of the lung and inflammation of the mediastinum made the dissection lengthy and difficult, and after removal of the growth it was decided to postpone the mobilization of the stomach to a later date. The upper œsophagus was therefore left as a fistula near the suprasternal notch, while the lower œsophagus was brought to the surface of the epigastrium. Post-operative bronchopneumonia with gangrene of the right lower lobe resulted in an empyema which was drained, but later required a partial thoracoplasty to obliterate the cavity. The patient improved after this, but he was much troubled by persistent regurgitation from his lower fistula and he failed to put on weight. Eight months after the œsophagectomy it was therefore decided to proceed to the mobilization of the stomach into the presternal position. During this procedure a second empyema was found presenting at the œsophageal hiatus of the diaphragm, where it was closed off below by the spleen and stump of the œsophagus. This was evacuated and drained from below and the presternal operation was completed, but the patient died a week later.

The post-mortem showed that the mediastinal empyema connected with a necrotic area of the inner surface of the lower lobe of the right lung. There was no secondary growth in the mediastinum and the stomach had not sloughed in its new position, but was adherent by fibrinous tissue to the skin and the front of the chest wall.

*Case 2.*—This case was more encouraging; the patient was a woman aged 60 who had lost  $4\frac{1}{2}$  st. in weight and suffered from dysphagia due to a growth in the lower part of the œsophagus, the upper edge of which was 3 in. above the cardia. Her operation was performed on April 2, 1943, the anæsthetic being given by Mr. Stout. A right thoracotomy was again chosen, the lower 5 in. of œsophagus were removed together with a fringe of gastric mucosa, and the complete operation of presternal œsophago-gastrostomy was performed uneventfully in one stage. Bronchopneumonia with empyema again supervened, but cleared up after drainage and healed during the next four months. The anastomosis broke down six days after operation and formed a fistula about 1 in. across, with upper and lower openings. These were connected by an indwelling plastic tube through which the patient was able to take liquid or soft solid foods by mouth.

The specimen was reported as a columnar-celled adenocarcinoma by Dr. W. W. Woods, although at operation it had not appeared to extend to the cardia. Seven months after the œsophagectomy the fistula was explored and some nodules of growth were found in the gastric mucosa, with a metastatic gland on the lesser curve. The whole stomach was therefore mobilized once more and a partial gastrectomy was performed from the cardiac end, the line of section being two-thirds the distance along the lesser curve and one-third the distance along the greater curve.

It was surprising to find that even now a direct anastomosis could be made without tension between the end of the œsophagus and the greater curve of the stomach. Unfortunately post-operative infection of the presternal cellular tissue caused a further breakdown of the anastomosis which healed but left a gap of 3 in. between the œsophageal and gastric openings.

This patient has been discharged home with an indwelling plastic tube across the fistula; she lives a fairly normal life, taking soft foods by mouth and has put on 19 lb. in weight. She removes the tube at night and replaces it in the morning in order to keep it fairly watertight. If the tube gets blocked she takes it out, cleans it and puts it back, though this is seldom necessary. She has no trouble with regurgitation into her mouth and the disability of the fistula is not at present sufficient to warrant a further operation. She is, however, unable to exert herself, as this causes the fistula to leak. Full of courage, she proposes to come into hospital for plastic closure of the fistula.

*Case 3.*—The third patient was a fairly healthy man of 48 with three months' history of lassitude, loss of weight, and difficulty in swallowing solid foods due to a columnar-celled carcinoma of the cardia. His operation was performed on Feb. 29, 1944, cyclopropane and oxygen being administered by Dr. Parry Brown. Through a left abdomino-thoracic incision the growth was found to extend right across the fundus of the stomach and 1½ in. up the œsophagus, which opened into the base of a large malignant crater. There was one indurated œsophageal lymph-node, several outside the cardia, and a mass of glands around the root of the coronary artery, but the growth itself had not broken through the outer coat of œsophagus or stomach. The mass was too extensive to permit of endothoracic anastomosis, but after resection from 3 in. above the cardia to a line joining the incisura and the middle of the greater curve of the stomach, a presternal œsophago-gastrostomy was arranged without tension. A satisfactory excision of the growth and glands was obtained, but in spite of transfusion and high oxygen concentration in the respiratory gas a progressive circulatory collapse developed and the patient died two hours after the operation.

Post-mortem examination showed a small tear ½ in. long in the right mediastinal pleura with a partial right pneumothorax. Air had been able to enter but not to escape from the right side of the chest, and although partial inflation of the lung had been maintained by positive pressure, the pulmonary blood-flow had been gravely constricted and collapse of the general circulation had followed.

## DISCUSSION

These cases were to some extent experimental, but although they were in many ways disappointing, they do indicate the general feasibility of the plan of operation as well as some of the difficulties and dangers that may be encountered. Naturally, there is much to be learnt in the further development of the technique, but it is hoped that the method may prove a step forward in the treatment of carcinoma in this region, since it offers immediate restoration of swallowing if primary healing is obtained. On the other hand, it is noteworthy that breakdown of the anastomosis

is not fatal as it would be inside the thorax, and that the fistula which results is easily controlled by a short indwelling tube and may be repaired at leisure by a further adjustment of the stomach upwards.

The reduction of blood-supply involved in transposing the viscera into the presternal position is apparently not incompatible with their survival. In neither of the two cases in which the whole stomach was mobilized was any change observed in the colour of the fundus, and, in fact, no necrosis occurred post-operatively. Kirschner made similar observations in 1920 in utilizing the same degree of mobilization of the stomach to by-pass a simple stricture of the œsophagus in 5 cases. He found no evidence of deficient circulation at operation, and post-mortem examination of 4 patients who died showed no sloughing of the stomach, although one contained an acute ulcer. The patient who survived was observed for two years, during which time she ate a full diet and had a normal digestion. My second case also has no disturbance in this way, although her food has to be finely divided.

The blood-supply of the transposed œsophagus is derived from the descending œsophageal branches of the inferior thyroid vessels. These are apparently able to maintain a sufficient blood-flow to the lower middle œsophagus on account of the longitudinal direction of the intrinsic vessels in the œsophageal wall, but for this reason it is important to avoid trauma to the gullet and its superior connexions during the dissection. Doubts on the viability of the lower œsophagus when separated from its inferior vessels have mostly been expressed to explain the breakdown of an endothoracic anastomosis, but other factors are enough to account for this. In the 3 cases described, the blood-supply to the œsophagus was, in fact, adequate; *Case 1* was a high resection with only a short upper œsophageal stump, but in the other 2 cases the gullet was divided 5 in. and 3 in. from the cardia respectively. It survived uneventfully in the former case and although the last patient did not recover from the operation, the end of the œsophagus was observed to ooze when it was divided above the clamp.

The greatest danger to the patient after recovery from operative shock is that of infection of the pleural effusion from the bronchopneumonic lung. I have not yet had the opportunity of injecting penicillin into the pleural cavity after aspirating the fluid, but its effectiveness in early empyemata suggests that this may be a valuable preventive measure.

Although the operation was primarily designed to obviate the necessity for a skin tube after mid-upper œsophageal resection, its applicability to the lower œsophagus and cardia gives the surgeon greater freedom of action when exploring a growth here. His aim must be to perform an intrathoracic resection and anastomosis if possible, since it involves so much less anatomical disturbance, but he may find that the extrathoracic

method described is necessary to secure complete removal of the type of growth that spreads longitudinally up the œsophagus or widely into the stomach.

Technical feasibility is, however, not the only factor involved in the choice of method. As experience grows, the relative mortality, post-operative disability, and the incidence of recurrence of growth will become of increasing importance. These may be left to the future, but it is worth noting that a gastro-œsophageal junction immediately under the skin has certain advantages. Thus it may be manipulated if food is held up there, or it may be compressed if regurgitation due to lack of a cardia is troublesome, as it tends to be with an intrathoracic anastomosis.

More important perhaps is the fact that it can be palpated periodically for recurrent growth, which would then be accessible to X-ray treatment. Alternatively, it may well be that routine post-operative radiotherapy to the superficial stomach and œsophagus would give better long-term results in this form of cancer than are obtainable by operation alone.

I should like to thank the Royal Society of Medicine for allowing me to demonstrate *Case 2* at a recent meeting of the Clinical Section, and especially to thank my assistants and anaesthetists and the Sisters and Nurses of the London Hospital for their untiring skill and devotion in the care of these patients.

## BILATERAL RENAL CARCINOMA

By HOWARD G. HANLEY

SURGEON, HILLINGDON COUNTY HOSPITAL, MIDDLESEX; HON. UROLOGICAL REGISTRAR, ST. PAUL'S HOSPITAL, LONDON

BILATERAL renal carcinoma is a very rare finding, only about 9 cases being recorded in the literature. In reporting these, the various authors set different standards for accepting the few published cases, but nearly all agree that the diagnosis must eventually be confirmed by post-mortem examination, since the radiological findings may be deceptive.

Most of the authors present their cases as examples of two primary growths, the evidence used against one being a metastasis from the other varying in individual cases.

If there are no other metastases in the body and the renal veins are not involved, it is argued that the likelihood of a solitary secondary deposit in the opposite kidney is remote. Certainly in some case-histories there is such a long interval of time between the discovery of the two growths that there is strong evidence for supposing them to be of separate origin.

However, this question would seem to be idle speculation in most cases, since proof either way is not available.

All but one of the recorded cases are 'hypernephroid' carcinomas or Grawitz tumours, the exception being a bilateral papillary carcinoma of the renal pelvises.

### SUMMARY OF THE LITERATURE

The first example of a bilateral hypernephroma was recorded by Chute in 1910. The tumours were found post mortem, and there was a secondary deposit in the gut.

In 1914 Parkes Weber described a case of bilateral "malignant hypernephroma" or "adrenal carcinoma". He states that "doubtless the primary growth in the present case was suprarenal". However, this is accepted as an example of bilateral renal hypernephroid

carcinoma by some of the other authors. Unfortunately no microphotographs are reproduced, but the description of the gross specimens would seem to indicate an adrenal rather than a renal origin, and I am informed in a personal communication from the author that he still considers his case to have been a bilateral primary adrenal carcinoma, not a renal 'hypernephroid' carcinoma. Parkes Weber's case is, therefore, not included in the total of nine. In 1927 Kinney described a case where the diagnosis was made by retrograde pyelography, but confirmation was never obtained by autopsy examination, and for this reason it is not accepted by the more recent authors, notably Beilin and Neiman. Hunt's case in 1927 is quite straightforward. Nephrectomy was performed for "hypernephroma", and when the patient died, a similar growth was found on the other side; no metastases were found.

Sanford in 1931 performed a nephrectomy for a papillary carcinoma of the renal pelvis, although the other side was suspect radiologically. After death a full post-mortem examination was not allowed, but the remaining kidney was obtained and showed a similar papillary carcinoma. In the absence of radiological evidence of lung metastases he assumed that there were none present.

In 1935 Spengler and Bohrod described 2 cases. The first was diagnosed before death and confirmed by autopsy examination. No secondary deposits were found. In the second instance the tumours were found post mortem, together with multiple secondary deposits in the lung, liver, pancreas, and adrenals, while the right renal vein was filled with tumour tissue.

In 1940 Elward and Spire found bilateral hypernephroma masses after death in a case of

mediastinal neoplasm which had been treated by deep therapy. There were no renal symptoms.

In June, 1942, Forsythe recorded a case of nephrectomy for hypernephroma, followed by the finding of a similar growth on the other side post mortem. He also records a Mallory case-report No. 22091 in 1936, where nephrectomy was followed by the finding of a hypernephroma in the remaining kidney after death 13 years later. There were no metastases. I have been unable to verify this case personally.

In December, 1942, Beilin and Neiman described their case, confirmed by post-mortem examination 103 months after the original nephrectomy for hypernephroma.

These authors quote Siebke (1926) as having described 2 cases, but I am unable to confirm this from the reference given.

The same authors quote Lubarsch as describing 1 case, but on referring to the original paper, I find that Lubarsch includes 1 case of bilateral renal carcinoma in a large series of renal neoplasms which he is reviewing; no details or further references are given. He has seen no case of bilateral hypernephroma, so we may conclude that the case he refers to was a papillary carcinoma. In the absence of clinical data it is not included in the total of recorded cases.

This makes a total of 9 cases of proved bilateral renal carcinoma in the literature, with Kenny's case as a possible tenth.

A further case of bilateral renal carcinoma of the hypernephroma type is now presented.\* The provisional diagnosis was made radiologically and was subsequently proved at post mortem.

Owing to the absence of positive proof, it is not claimed that this was an example of two primary renal growths, although there is reason for supposing it may have been, especially when compared with the previously accepted cases.

### CASE REPORT

J. R., an alert, active, old-age pensioner of 73 years, with no previous or family history of renal disease, was first seen in out-patients in March, 1943, complaining of occasional blood in his urine during the previous three weeks. He had been losing much weight and complained of a painful lump in his right loin, which clinically was a large kidney tumour; his urine contained bright red blood, but was sterile on culture. Other than bronchitic signs in his chest, a general examination revealed no gross pathology. On admission to hospital, intravenous urography showed no excretion from the right kidney up to one and a half hours, while visualization of the left kidney was also very poor. Cystoscopy was performed, when bright blood was seen issuing from the right ureteric orifice; the left efflux was clear.

Owing to the poor visualization of the left kidney in the excretion urogram, a left ascending pyelogram was deemed necessary before performing a right

nephrectomy. Most unexpectedly this showed complete amputation of the upper group of calices, the appearance being that of a neoplasm or cyst (Fig. 330, B). This left kidney was neither tender nor palpable, while the urine collected from the ureteric catheter showed a few red blood-corpuscles but no other abnormality. A provisional diagnosis of left hypernephroid carcinoma was made.

A week later a right ascending pyelogram was performed under X-ray screen control but no filling of any calices could be obtained (Fig. 333, A). Blood was still passing down this ureter, and thus with the



FIG. 330.—A, Right ascending pyelogram. No filling of renal pelvis could be obtained. B, Left ascending pyelogram, showing complete amputation of upper group of calices.

provisional diagnosis of bilateral renal carcinoma the man was discharged home to be seen regularly in the out-patient department.

The hæmaturia decreased and even ceased completely for days at a time, but he was readmitted two months later with an acute bronchitis. His renal function was found to be unaltered, and a repeat chest radiograph still showed no evidence of intrathoracic secondary deposits. The lower pole of his left kidney was now just palpable, while the right kidney was much larger and more fixed.

The bronchitis subsided quickly and he was again under observation in out-patients for a period of eight months, during which time the hæmaturia and bronchitis were his chief symptoms. The left kidney was slowly enlarging.

He was readmitted in November, 1943, with bronchitis, but his general condition had deteriorated considerably. He had lost weight, was bleeding continuously, and both kidneys were painful, necessitating morphia to control the spasms at times.

During this period a large left varicocele developed but caused little discomfort. He became steadily weaker and died in December, 1943, ten months after the onset of symptoms.

### SUMMARY OF SPECIAL INVESTIGATIONS.—

**Radiography.**—March 13: Well-marked Paget's disease in pelvis and lumbar spine. **Excretion urography**—virtually no excretion from right kidney up

\* This patient was demonstrated at the Urological Section of the Royal Society of Medicine on Nov. 25, 1943. The gross specimen was shown at the Surgical Section of the Royal Society of Medicine on Jan. 5, 1944.

to 1½ hours. *Left*—very poor excretion and visualization. *Left ascending pyelogram*—amputation of upper group of calices due to neoplasm or cyst. *Chest*—no evidence of metastases.

March 22: *Right ascending pyelogram*—lack of filling of any calices.

Nov. 12: *Chest*—no evidence of intrathoracic metastases. *Spine, pelvis, leg bones, skull*—no evidence of metastases. *Paget's disease*—spine and pelvis.

Nov. 13: R.B.C. + + +, pus cells +, casts 0, coliform bacilli +.

*Blood.*—

March 17: R.B.C. 4,130,000 per c.mm., hæmoglobin 80 per cent, C.I. 1.0.

Nov. 22: R.B.C. 5,200,000 per c.mm., hæmoglobin 62 per cent, C.I. 0.6.

Nov. 12: *Serum phosphatase*—alkaline 8.2 units per 100 ml; acid 2.4 units per 100 ml

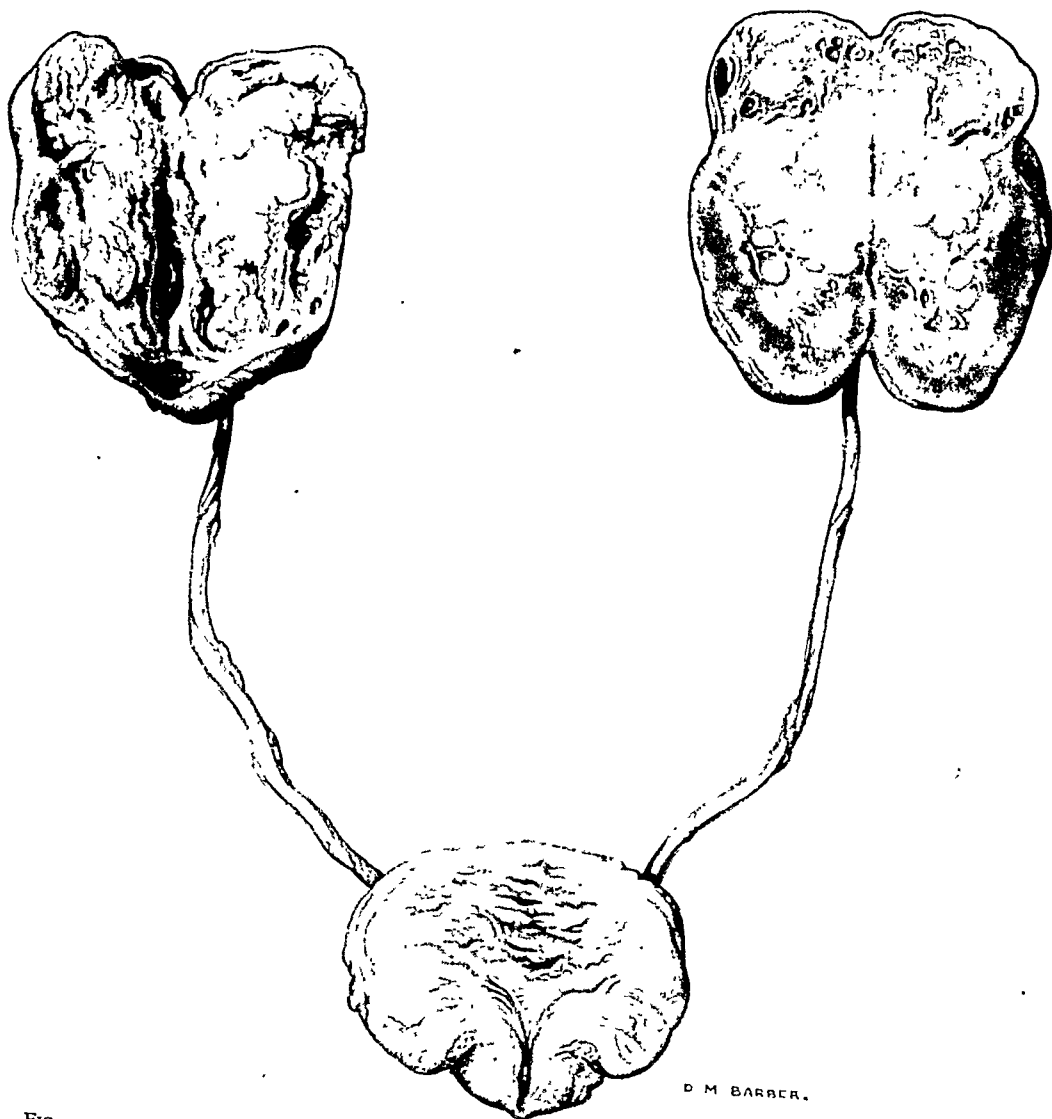


FIG. 331.—Gross specimen showing a typical 'hypernephroma' in the upper half of the left kidney, and a shapeless mass of necrotic growth filling up the right kidney.

## Renal Function.—

March 16:	Blood-urea	45 mg. per cent
May 29:	" "	43 mg. " "
Nov. 12:	" "	56 mg. " "
Dec. 10:	" "	54 mg. " "

## Urine.—

March 13: R.B.C. + + + +, pus cells +, casts 0, organisms 0.

*Wassermann and Kahn.*—Negative.

*Blood-pressure.*—160/85.

*Pulse and Temperature.*—Normal throughout.

*At Autopsy.*—A post-mortem examination performed by Dr. Bray confirmed the diagnosis of bilateral renal neoplasms. Several small nodules on the parietal pleura, which subsequently proved to be secondary hypernephroma deposits, were the only evidence of general metastases.



**PATHOLOGY.**—The *macroscopical* appearance of the two kidneys and bladder is shown in Fig. 331. The left kidney contained a typical 'hypernephroma' in the upper pole with normal tissue below it. The right kidney, greatly enlarged and shapeless, contained much old and recent blood-clot and collapsed to half its size when cut open. There was a firm, organized, cone-shaped clot blocking the pelvi-ureteric junction while the majority of the dilated sac contained a yellow necrotic papilliferous mass of tissue, nowhere resembling a 'hypernephroma'. There was no evidence of extension along either renal veins, in spite of the recent onset of a varicocele on the left side.

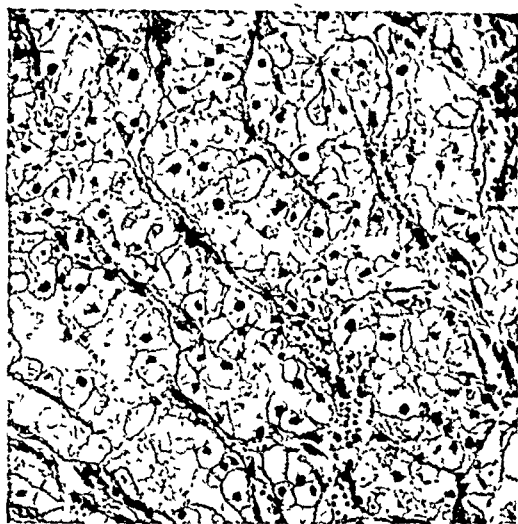


FIG. 332.—Microphotograph of section from left kidney tumour. ( $\times 150$ .)

There was no evidence of growth extending along either renal veins, but there were several small metastatic nodules on the parietal pleura. These were not shown in repeated radiographs of the chest.

3. No special claim is made that the case is an example of two primary growths, although similar cases in the literature have been accepted as such.

I would like to express my gratitude to Professor J. Henry Dible for his opinion on the



FIG. 333.—Microphotograph from growing edge of necrotic area in right kidney. ( $\times 150$ .)

**Microscopy.**—Sections from the left kidney showed typical 'hypernephroma' tissue (Fig. 332).

Professor J. Henry Dible, who selected and examined sections from the right kidney for me, reports that two distinct types of cells could be seen, a papilliferous area, and the more typical 'hypernephroma' tissue.

The necrotic material from the distended pelvis showed a papilliferous structure in the areas where any histology could be made out, but a section from the growing edge of this same tissue showed the typical 'hypernephroma' cells (Fig. 333).

### SUMMARY

1. The previously reported cases of bilateral renal carcinomas are reviewed.

2. A further case is added to the literature, making ten in all. The provisional diagnosis was made radiologically before death, and was subsequently confirmed by post-mortem examination.

pathological specimen and his kind help with the slides and microphotographs.

I am also grateful to my colleague, Mr. L. Fatti, for his help with the German literature.

### REFERENCES

- BEILIN, M. L., and NEIMAN, B. H. (1942), *J. Urol.*, **48**, 575.  
 CHUTE, A. L. (1910), *Trans. Amer. Ass. gen.-urin. Surg.*, **5**, 181.  
 ELWARD, J. F., and SPIRE, R. L. (1940), *Radiology*, **35**, 274.  
 FORSYTHE, W. E. (1942), *J. Urol.*, **47**, 784.  
 HUNT, V. C. (1927), *Surg. Clin. N. Amer.*, **7**, 1462.  
 KINNEY, W. H. (1927), *J. Urol.*, **18**, 533.  
 LUBARSCH, O. (1924), *Handbuch der spec. path. Anat. u. Histol.*, 6 (pt 1, 607). Berlin: J. Springer.  
 SANDFORD, H. L. (1931), *Surg. Gynec. Obstet.*, **53**, 360.  
 STEBKE, H. (1926), *Z. Krebsforsch.*, **23**, 66.  
 SPENGLER and BOHRD (1935), *J. Urol.*, **33**, 427.  
 WEBER, F. P. (1914-15), *Proc. R. Soc. Med. (Med. Sect.)*, **8**, 6.

## TRAUMATIC ISCHÆMIA OF PERIPHERAL NERVES WITH SOME OBSERVATIONS ON VOLKMANN'S ISCHÆMIC CONTRACTURE

By ATHOL R. PARKES

SURGEON-IN-CHARGE, PERIPHERAL NERVE INJURIES UNIT, SCOTTISH E.M.S.

A NUMBER of cases of injury to a limb complicated by multiple nerve lesions has been seen at a Peripheral Nerve Injuries Centre in Scotland. The aetiology of the nerve lesions was at first obscure, but the conclusion has now been reached that they are due to ischæmia of the nerve trunks, the main factor in the production of which was in most cases pressure of extravasated blood and tissue fluids beneath the deep fascia of the limb.

### CASE RECORDS

Most of the patients had been injured some months before their first attendance at the Centre.

#### LOWER LIMB

Case No. 1.—D. Y., aged 21.

HISTORY.—This naval officer was kicked on the leg while playing football and sustained a simple transverse fracture of the tibia and fibula about

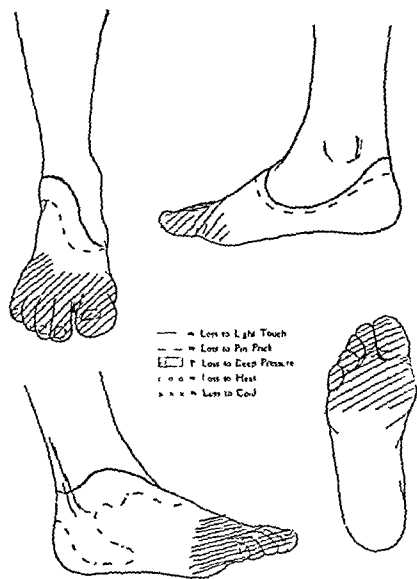


Fig. 334.—Chart showing sensory loss in the distal part of the distribution of musculocutaneous, anterior tibial, posterior tibial, and sural nerves. Note extension of sensitivity to pin-prick along sural distribution.

midshaft. Within a few hours the leg became very swollen and tense, and because of this plaster was not immediately applied. About twelve hours after the injury the patient noticed numbness of the great toe, and this numbness gradually spread centripetally until the whole foot felt 'dead.' The notes state that the posterior tibial pulse at the ankle was not palpable at this time. After five days of elevation of the limb a walking plaster was applied.

EXAMINATION (5 months after injury).—The posterior tibial and dorsalis pedis pulses were normal at the ankle. There was moderate clawing of the toes with slight contracture in long extensor and flexor tendons.

Motor: There was wasting and paralysis of all the intrinsic muscles of the foot—extensor digitorum brevis as well as those of the sole—and all these muscles gave R.D. on electrical testing. All the muscles of the leg showed full voluntary power and a normal response to faradism.

Sensory: There was loss of sensation to light touch and pin-prick in the areas of distribution of all the deep nerves of the leg—anterior tibial, posterior tibial, and musculo-cutaneous—and in the area of the sural nerve (Fig. 334). Deep pressure sense and joint sense were absent in the distal part of the foot.

Sweating: There was anhydrosis in the anæsthetic area.

RECOVERY.—The first sign of sensory recovery was noted 6½ months after injury and it slowly progressed in all areas in a manner indicative of nerve regeneration. Seventeen months after injury recovery of sensation was almost complete in musculo-cutaneous, anterior tibial, and sural areas, but there was still some loss to light touch in the distal part of the sole. Some return of voluntary power and some response to faradism were noted in abductor hallucis. During recovery there was a very marked 'protopathic' type of response to pin-prick, especially on the sole. There was a definite delay (about 1.5 seconds) in the appreciation of the stimulus and the sensation evoked thereby was of an extremely unpleasant character. Rubbing the skin of the sole also gave rise to a very unpleasant sensation ('plantar dyesthesia'), and at this stage of recovery there was a good deal of pain on walking. These phenomena became much reduced in intensity as sensation to light touch was regained. The slight shortening of the long flexor and extensor tendons gradually developed into a fairly severe contracture which has recently been treated by operation.

Case No. 2.—T. G., aged 25.

HISTORY.—This soldier was struck by a car and sustained a 'bumper' fracture of the upper end of the tibia. Despite considerable swelling of the leg a closed plaster was applied, but had to be removed the following day because of poor circulation in the foot. Skeletal traction on a Braun's splint was substituted and later a drop-foot was noticed. The patient could give no clear history regarding the onset of anæsthesia.

EXAMINATION.—The findings were similar to those in Case 1, except that extensor hallucis longus was paralysed and there was marked weakness of other muscles supplied by the lateral popliteal nerve. Sensation was present in the sural distribution, but lost in the distal part of the saphenous area (Fig. 335).

RECOVERY.—The first sign of sensory recovery was noted seven months after injury, and later delayed 'protopathic' response to pin-prick was much in

evidence. When last examined fifteen months after injury all muscles were active, though the anterior tibial muscles were still weak. Sensory loss was

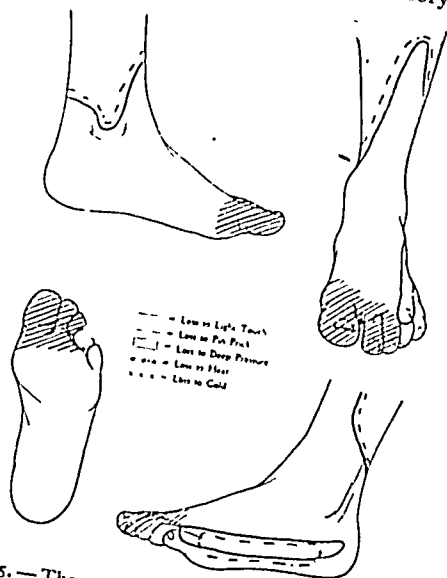


Fig. 335.—The sensory loss involves the distal part of the saphenous distribution, but the sural area has escaped.

confined to the distal part of the sole and the delayed response to pin-prick could not be demonstrated. There was no obvious muscle contracture.

Case 3.—R. L., aged 18.

HISTORY.—Both legs crushed by a heavy boulder during an air raid. The right leg had to be amputated. On the left side there was no fracture and the skin was intact, but the leg was greatly swollen for about a week after the injury. It was not until seventeen months after the injury that this patient was first seen at the Centre.

EXAMINATION.—There was paralysis and R.D. in all intrinsic muscles of the foot and loss of sensation to light touch over the whole foot except in the saphenous distribution and over a small area on the sole. There was a corresponding loss to pin-prick, except that over most of the sole there was hyperalgesia with a delayed response (Fig. 336).

RECOVERY.—Thirty months after injury there was practically complete recovery of sensation and some return of voluntary power to the intrinsic muscles of the sole. There was no contracture.

Case 4.—R. McN., aged 19.

HISTORY.—Closed comminuted fracture of the tibia at the junction of its middle and lower thirds in a railway accident.

EXAMINATION.—There was loss of function in all three deep nerves of the leg and in the sural nerve. The long extensor and long flexor of the great toe were paralysed, as well as the intrinsic muscles of the foot.

RECOVERY.—Nine months after injury there was some recovery in the posterior tibial nerve.

Case 5.—D. B., aged 37.

HISTORY.—Closed comminuted fracture of tibia and fibula caused by a heavy weight falling on the leg. The fracture was about the middle of the leg.

EXAMINATION.—The findings were very similar to those in Case 4, except that extensor hallucis longus was the only leg muscle affected.

RECOVERY.—Fourteen months after injury there was considerable sensory recovery in all affected nerves and some voluntary power in abductor hallucis.

Case 6.—J. H., aged 20.

HISTORY.—Accidental through-and-through bullet wound just below the knee, which caused a comminuted fracture of the upper end of the tibia without displacement. The leg was put up in plaster. Two months after injury the patient was examined at another Peripheral Nerve Injuries Unit, where all the muscles below the knee were found to be paralysed and to give R.D. There was sensory loss in the areas of distribution of all the deep and superficial nerves below the knee. The posterior tibial pulse was palpable at the ankle. Exploration: The nerves and vessels were explored in the popliteal fossa and upper part of the leg, but no abnormality was seen.

RECOVERY.—Three months after injury there was some return of voluntary power to the calf muscles and peronei. Twenty-one months after injury voluntary power had returned to all the muscles of the leg and sensory recovery was progressing, but a severe contracture had developed in both anterior and posterior tibial muscles.

EXPLORATION.—To correct the deformity resulting from the above contractures an operation was performed by Mr. Roland Barnes, and this provided an opportunity of inspecting the structures in the lower part of the posterior compartment of the leg. Flexor hallucis longus showed the typical appearance of a true Volkmann's ischæmia, the muscle substance

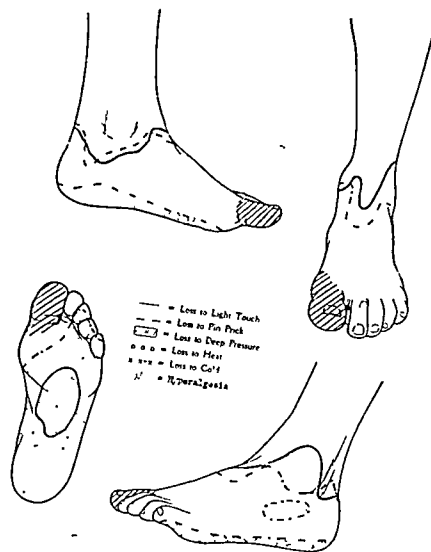


Fig. 336.—In this case there has been some recovery of sensation in the posterior tibial and sural areas.

being replaced by a homogeneous yellow mass with a sheath of dense fibrous tissue. All the other muscles appear normal. There was good pulsation in the posterior tibial artery, but none in the peroneal.

BIOPSY.—Specimens were obtained from flexor hallucis longus, flexor digitorum longus, and soleus. On histological examination only the first-named

showed the typical mass necrosis and fibrous tissue replacement of Volkmann's ischæmic contracture (Fig. 337). The others showed only some degenera-

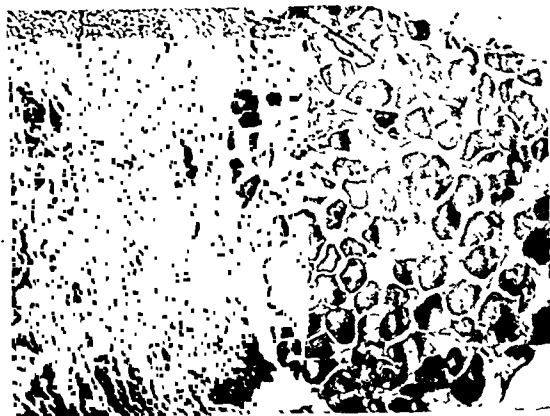


FIG. 337.—Transverse section of flexor hallucis longus eighteen months after injury, showing completely necrotic muscle with dense scar tissue at its periphery.

tion of muscle-fibres with interfibrillary fibrosis on the surface of the muscles.

**Case 7.—J. M., aged 25.**

**HISTORY.**—Through-and-through bullet wound of the leg about its middle, which caused a comminuted fracture of the fibula. The wounds were excised and sutured. Three days later the leg became very swollen and tense, and anæsthesia of the foot was noticed.

**EXAMINATION.**—Three weeks after injury the posterior tibial and dorsalis pedis pulses were normal at the ankle. There was loss of function in all three deep nerves of the leg with paralysis of the long flexor and long extensor of the great toe.

**EXPLORATION.**—Some months later the posterior tibial nerve was explored. There was no sign of division, but the nerve was thin and atrophic below the level of the injury.

**RECOVERY.**—Twenty-one months after injury there was no motor recovery, but considerable recovery of sensation, especially in the musculo-cutaneous distribution.

**Case 8.—D. McK., aged 33.**

**HISTORY.**—Through-and-through bullet wound of the thigh. The track of the bullet did not pass near the sciatic nerve, but it did traverse Hunter's canal.

Two days later there was a marked bruit and visible pulsation in the region of the femoral vessels, but the pulse was palpable at the ankle. There was no evidence of nerve lesion at this time. During the next six weeks the patient was in considerable pain and the pulsating swelling in the thigh gradually enlarged.

44th day: Notes state that there were no active movements at the knee, ankle, or toes, and no sensation to touch in the foot or to passive movements of the toes.

46th day: **Operation.** A communication between the superficial femoral artery and vein was excised and a large hæmatoma evacuated from the thigh. The wound was closed without drainage. The day following this operation the foot was very cold, but thereafter the circulation rapidly improved.

51st day: There were slight flickering movements in the toes and, though sensation was normal above the ankle, it was lost over the foot except on the medial side. Joint sense was absent in the toes. There was a moderate degree of swelling of the thigh.

52nd day: Active movements at the ankle and toes were present, and sensation was present over the greater part of the sole, as well as along the medial border of the foot.

53rd day: Marked deterioration in movements at the ankle and toes and no sensation to touch below the knee.

55th day: Anæsthesia now more or less 'stocking' below the tibial tuberosity.

58th day: Only slight flickering movements at ankle and toes. Circulation through the foot good, despite some œdema.

60th day: *Forty-one ounces* of thick altered blood and pus evacuated from thigh and cavity drained.

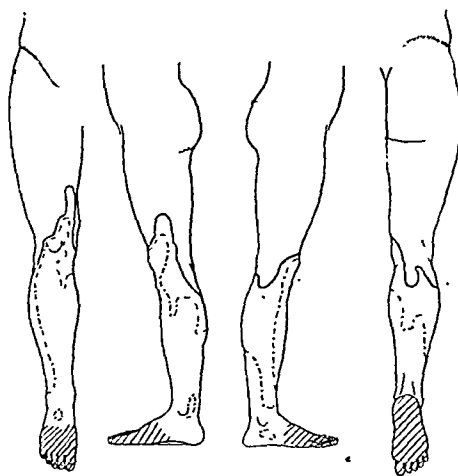
71st day: Movements slowly returning to leg and foot.

98th day: **Electrical Reactions:** No response to faradism in muscles of leg.

Seven and a half months after injury there was good voluntary power in the calf muscles and weak voluntary activity in some of the proximal muscles of the leg. Anæsthesia still present.

**EXAMINATION.**—When first examined at the Centre twelve months after injury, the pulse at the ankle was strong and there were no signs of any muscle contracture.

**Motor:** The muscles of the thigh and the more proximal muscles of the leg had good voluntary power, but the long extensor and long flexor of the great toe were very weak and all the intrinsic muscles of the foot were paralysed.



— = Loss to Light Touch  
- - - = Loss to Pin Prick  
□ = Loss to Deep Pressure  
• • • = Loss to Heat  
+ + + = Loss to Cold

FIG. 338.—Showing more or less stocking anæsthesia to light touch, but with areas of sensitivity to pin-prick in the proximal parts of the areas of distribution of saphenous, musculocutaneous, posterior tibial, and sural nerves.

**Sensory:** Sensation to light touch was lost over the whole sciatic area and also in the areas supplied by the saphenous nerve and the medial cutaneous nerve of the thigh. There was slight sensation to pin-prick in the proximal part of the areas supplied

by saphenous, musculo-cutaneous, sural, and posterior tibial nerves (*Fig. 338*). Deep pressure and joint sense were lost over the distal half of the foot.

**Vasomotor:** The affected foot was warmer than the other.

**Sudomotor:** Small patches of sweating were present below the knee only in those areas noted above where there was some sensation to pin-prick.

**RECOVERY.**—When re-examined fifteen months after injury there were no obvious signs of further recovery in the nerves, and a slight contracture had developed in the calf and anterior tibial muscles.

Eighteen months after injury there was some return of sensation to pin-prick in the posterior tibial and sural areas in the foot, with corresponding areas of sweating.

**Case 9.**—C. P., aged 34.

**HISTORY.**—This patient underwent a high ligation operation for bilateral varicose veins. On the right



**FIG. 339.**—Section of tibialis anterior, showing mass necrosis of muscle with scar tissue at the periphery. There is remarkably little cellular activity.

side the operation was difficult owing to the presence of a mass of dilated veins in the neighbourhood, and after 10 c.c. of sodium morrhuate had been injected into the distal segment the ligature slipped and there was brisk hæmorrhage into the wound from this portion of the vein. The vein had to be exposed at a lower level and ligated here before the bleeding was controlled.

The day following the operation the patient complained of very severe pain in the calf muscles and in the popliteal region. The gastrocnemius was swollen and very tender, and there was pain on pressure over the popliteal space. The leg and foot were pale, with dilated superficial veins. In addition the peroneal muscles were found to be paralysed, and there was loss of sensation over the whole foot except along its medial border.

The severe pain continued and two weeks after operation there was paralysis of peronei and tibialis anterior and marked weakness of all other muscles below the knee. There was complete sciatic sensory loss. Three weeks after operation there was a further brisk hæmorrhage from the wound, necessitating re-opening under general anaesthesia.

Three months after operation the patient was admitted to a Peripheral Nerve Injuries Unit where, apart from weak voluntary power in the muscles of the posterior compartment of the leg, there was

found to be a complete sciatic palsy. Subsequent notes from this Unit recorded progressive recovery in the medial popliteal nerve with a marked delayed response to pin-prick at one stage and little recovery in joint sense. The lateral popliteal nerve showed practically no sign of recovery.

**EXAMINATION.**—When first examined some months later no pulse could be felt at the ankle, and the popliteal pulse was weak compared with the opposite side. The foot became pale when elevated and cyanosed when dependent. There was some contracture of anterior tibial and peroneal muscles, but not in the posterior tibial group. The muscles in the anterior compartment felt extremely indurated.

**Motor:** There was satisfactory voluntary power in all the muscles of the posterior compartment, but apart from a flicker in the proximal fibres of tibialis anterior there was no activity in the muscles of the anterior and lateral compartments of the leg or in the intrinsic muscles of the foot.

**Sensory:** Complete sensory loss in the distribution of the lateral popliteal nerve, but considerable recovery in the medial popliteal, with some residual delayed response to pin-prick on the plantar aspect of the toes.

**BIOPSY.**—A piece of tibialis anterior was removed for examination. The naked-eye appearance of the muscle was typical of Volkmann's ischæmia and histological examination confirmed the presence of this condition (*Fig. 339*).

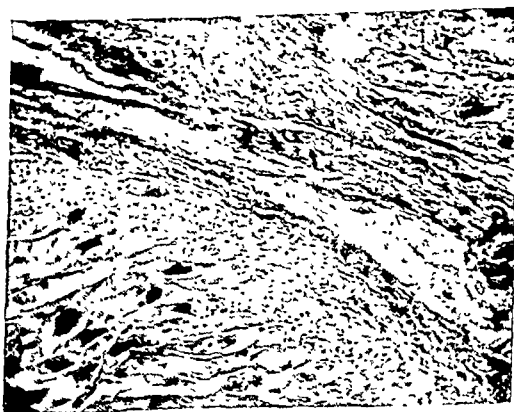
**RECOVERY.**—Three months after the above examination there was still further sensory recovery, especially in the medial popliteal distribution.

## UPPER LIMB

**Case 10.**—A. B., aged 28.

**HISTORY.**—Whilst cleaning his rifle this soldier accidentally shot himself through the right axilla. Profuse hæmorrhage from the wounds necessitated repeated blood transfusions but the axilla was not explored.

**EXAMINATION.**—On admission to the Centre ten days after injury the whole limb was grossly swollen but the radial pulse was palpable at the wrist.



**FIG. 340.**—Longitudinal section of biceps brachii in a case of injury to the axillary artery. The muscle is necrotic and is being replaced by dense scar tissue. Note cellular activity at the junction of muscle and fibrous tissue.

**Motor:** There was paralysis of all muscles below the shoulder with the exception of deltoid and triceps.

# TRAUMATIC ISCHÆMIA OF PERIPHERAL NERVES 407

**Sensory:** Sensory loss extended up to the level of the middle of the arm anteriorly and to the middle of the forearm posteriorly.

After the swelling had been reduced by placing the limb on an abduction splint it was noticed that the biceps was extremely indurated; it felt, in fact, like a typical Volkmann's ischæmia, and this diagnosis was later confirmed by biopsy (Fig. 340). No pulsation could be detected in the brachial artery, but the profunda vessel was pulsating strongly.

**RECOVERY.**—Ten months after injury there was quite good voluntary power in all muscles receiving their nerve-supply above mid-forearm, but no recovery in the more distal muscles. Sensation had recovered as far as the wrist, except in the superficial distribution where recovery was complete. Fifteen months after injury there was some recovery of sensation to pin-prick in the median distribution.

**Case 11.**—J. C., aged 28.

**HISTORY.**—Through-and-through bullet wound of the axilla. The axilla was explored a few hours after injury and a large axillary hæmatoma was evacuated. The axillary artery was found to have been damaged and the radial nerve had been divided. The median and ulnar nerves appeared to be intact. The artery was ligated.

**EXAMINATION.**—

**Motor:** Five months after injury there was, in addition to a complete radial-nerve palsy, paralysis of all the intrinsic muscles of the hand. All the paralysed muscles gave R.D.

**Sensory:** Complete sensory loss in median, ulnar, and superficial radial areas. A hard mass of almost cartilaginous consistence was felt in the substance of the long and lateral heads of triceps, and the muscles of the forearm also felt somewhat indurated. Subsequent biopsy of these muscles showed the typical Volkmann appearance only in triceps (Fig. 341).

**EXPLORATION.**—Division of the radial nerve was confirmed and suture was performed. There was no obvious abnormality of the median and ulnar nerves.

**RECOVERY.**—Sensory recovery is taking place in the median area, but there is not as yet any activity in the intrinsic muscles of the hand.

**Case 12.**—G. E., aged 28.

**HISTORY.**—G.S.W. of upper arm, causing a compound comminuted fracture of the humerus.

The wounds were excised and plaster was applied. Following this the circulation in the hand was very poor and the forearm and hand became cyanosed. The radial pulse was absent for the first few days after injury.

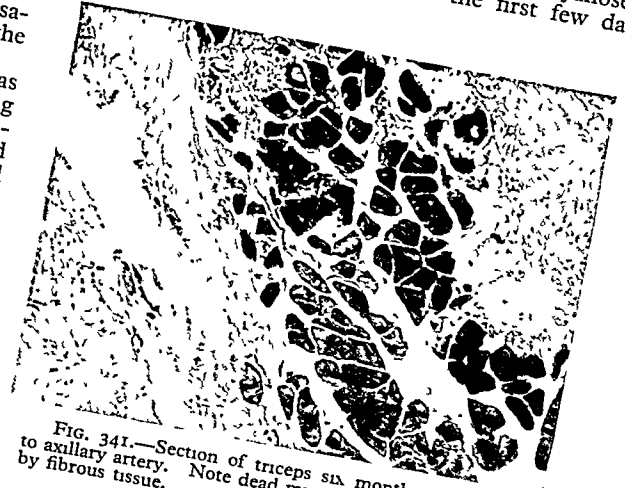


FIG. 341.—Section of triceps six months after injury to axillary artery. Note dead muscle mass being replaced by fibrous tissue.

**EXAMINATION.**—The findings were almost the same as those in the previous case, including division of the radial nerve. Volkmann's ischæmic contracture of the forearm muscles was suspected, but muscle biopsy did not support this.

**Case 13.**—T. P., aged 32.

**HISTORY.**—Closed fracture of the lower end of the ulna as a result of a motor-cycle accident. A skin-tight plaster was applied, and when this was removed some weeks later there were pressure sores in the region of the wrist—one of them immediately over the radial artery—and there was loss of sensation in the fingers.

**EXAMINATION.**—Five months after injury the radial pulse was present even beyond the site of the pressure sore. There was paralysis and R.D. in all the intrinsic muscles of the hand, with very poor responses to galvanism. Sensation to light touch was absent in all the fingers, but that to pin-prick was lost only over the distal phalanx of the index. At first no contracture of muscles was noticed, as full flexion and extension of the fingers was possible.

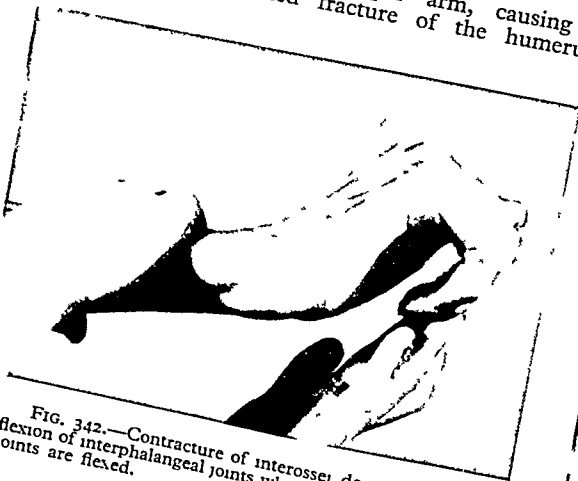


FIG. 342.—Contracture of interosseus does not prevent flexion of interphalangeal joints when metacarpophalangeal joints are flexed.



FIG. 343.—Contracture of interosseus prevents passive flexion of interphalangeal joints when metacarpophalangeal joints are held moderately extended.

More careful examination, however, revealed the presence of a moderately severe contracture of the interossei because of which it was found impossible passively to extend the metacarpophalangeal and flex the interphalangeal joints at the same time (Figs. 343, 343). There was also some restriction of lateral movements at the metacarpophalangeal joints.

**RECOVERY.**—Eight months after injury voluntary power had returned to most of the intrinsic muscles of the hand and sensation had almost completely recovered. The contracture of the interossei was becoming more severe.

**OPERATION.**—The tendons of the contracted interossei were divided by a palmar approach. This resulted in a considerable improvement in the function

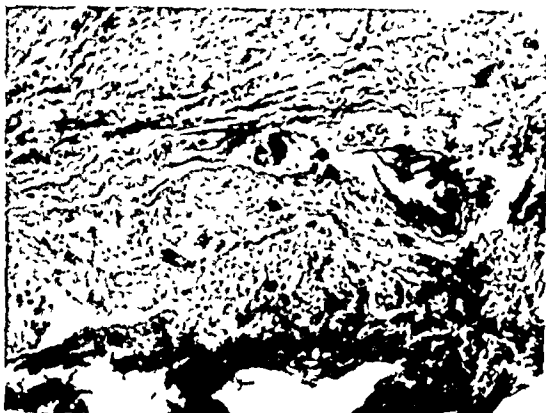


FIG. 344.—Section of fourth dorsal interosseous muscle. Note dense fibrous tissue engulfing a few dead muscle-fibres.

of the hand. At operation it was noted that the lumbrical muscles looked absolutely healthy. Portions of the affected interossei were removed for histological examination and the sections were most suggestive of Volkmann's contracture (Fig. 344).

**Case 14.**—B. T., aged 25.

**HISTORY.**—Wrist crushed between two vehicles and sustained a fracture-dislocation. Shortly after the injury the wrist became very swollen and the patient began to experience tingling in the middle three digits. The tingling persisted for four or five days and then the fingers became numb.

**EXAMINATION.**—

**Motor:** Voluntary power was normal in all intrinsic muscles of the hand.

**Sensory:** There was anaesthesia to light touch over the whole of the hand, with the exception of the area supplied by the dorsal branch of the ulnar nerve. Sensation to pin-prick absent over the distal half of the lateral three digits. Joint sense absent in the interphalangeal joints of the lateral three digits.

**Case 15.**—Mrs. M. S., aged 61.

**HISTORY.**—Fracture-dislocation of the right shoulder. Notes of examination before reduction state that there was paralysis of the circumflex nerve, but no sign of involvement of median, ulnar, or radial nerves. The dislocation was reduced and the following day there was marked swelling of the upper arm and 'impairment' of sensation in the hand, with inability to extend the interphalangeal joints. Three days after injury it was noticed that there was no pulsation in the arteries of the limb below the

subclavian, though the hand was warm and showed no evidence of impairment of the circulation.

**EXAMINATION.**—When admitted to the Centre one week after injury there was still considerable swelling and bruising of the shoulder region and upper arm. No pulsation could be felt in the arteries below the subclavian.

**Motor:** In addition to paralysis of the deltoid, no activity could be detected in any of the intrinsic muscles of the hand or in the muscles supplied by the ulnar nerve in the forearm.

**Sensory:** Ulnar, complete sensory loss. Median, loss of sensation to light touch and almost complete loss of sensation to pin-prick. Superficial radial, loss of sensation to light touch, but very striking delayed response to pin-prick.

**RECOVERY.**—Two days after the first examination the following points were noted:—

**Motor:** Weak voluntary power had returned to flexor carpi ulnaris.

**Sensory:** Ulnar, complete sensory loss. Median, loss of sensation to light touch persisted but a delayed response to pin-prick was present throughout the median area. Superficial radial, there was some appreciation of light touch and an immediate response to pin-prick.

Joint sense was absent in all the interphalangeal joints, except in the thumb.

Two days later still the results of sensory testing showed: Ulnar, striking delayed response to pin-prick and firm pressure. Median, as before.

Some weeks later the condition had remained unchanged, with no return of light touch sensation in ulnar or median areas and paralysis of all intrinsic muscles of the hand. The 'slow' pain response persisted.

## SUMMARY OF CLINICAL FEATURES

1. A history of injury to the limb followed by gross swelling or other signs of severe circulatory disturbance.

2. Evidence of disturbance of function, generally amounting to complete paralysis, in all the deep nerve-trunks of the affected part.

3. Sensory loss is generally more obvious than motor paralysis and, unless the nerves are 'concussed' by the initial injury, the anaesthesia is of gradual onset, commencing in the digits and spreading centripetally. It is frequently of the 'stocking' or 'glove' type and is sometimes thought to be 'hysterical'.

4. There may be some dissociation between various forms of sensation, especially during the early stages and during recovery, e.g., light touch sensation and joint sense are more likely to be lost than is sensation to pin-prick. A delayed response to pin-prick is a notable feature in most cases at some stage.

5. Motor loss, when present, is frequently confined to the intrinsic muscles of the hand or foot, though it may affect some of the more proximal muscles.

6. Muscle contractures are frequently present in the later stages, but they are usually of mild degree and are seldom of the true Volkmann type.

7. Spontaneous recovery occurs in most cases but, apart from that which may occur during the first few weeks after injury, it is very slow and is dependent upon nerve regeneration.

## AETIOLOGY

In considering the aetiology of the multiple nerve lesions in these cases the following possibilities suggest themselves:—

1. Direct mechanical injury to the nerve-trunks.
2. Involvement of nerve-trunks in scar tissue or callus.
3. Peripheral nerve-endings affected by circulatory disturbance.
4. Traumatic arterial spasm (or arterial ligation).
5. Pressure beneath the deep fascia due to extravasation of blood and tissue fluids, causing ischæmia of the nerve-trunks.

These factors will be considered in the above order. Hysteria was considered as a possible cause, but was ruled out because of the presence of muscular wasting and R.D. in paralysed muscles and loss of sweating in anæsthetic areas.

### 1. DIRECT MECHANICAL INJURY TO THE NERVE-TRUNKS

The multiplicity of the nerve lesions is obviously a point against this as a possible cause unless the lesions can be regarded as being due to 'concussion' of the nerve-trunks. If that were so early recovery would be expected. Moreover, in those cases where the nerves were explored (Cases 6, 7, and 11) there was no evidence of division or of direct pressure on the nerves, with the exception of the radial nerve in Cases 11 and 12. The cases with a history of gradual onset also preclude such a cause.

### 2. INVOLVEMENT OF NERVES IN SCAR TISSUE OR CALLUS

This could possibly be a cause in only a few of the cases, and even in those there are obvious objections. In nearly every case the nerve lesions were obviously present long before such factors could have become operative.

### 3. AN EFFECT OF THE CIRCULATORY DISTURBANCE ON THE PERIPHERAL NERVE-ENDINGS

That this may be a cause is suggested by the fact that the neurological defects are most marked in the distal parts of the limb. One would naturally expect that when the blood-supply to a limb is reduced to the point of ischæmia the effect on the nerves would be most intense at the periphery. It has, however, been shown experimentally by Lewis and his co-workers (1931) that although the effects are first observed at the periphery, they are due to ischæmia of the nerve-trunks. This view has received the support of other workers (Gasser, 1934; Clark, Hughes, and Gasser, 1935; Thompson and Kimball, 1936). Moreover, in the present series of cases, careful charting of the sensory loss and the manner of its recovery is definitely in favour of the lesion being situated in the nerve-trunks near the site of injury.

### 4. TRAUMATIC ARTERIAL SPASM (OR ARTERIAL LIGATION)

This is a subject about which much has been written in recent years (Griffiths, 1940; Cohen 1940-41; Barnes and Trueta, 1942). The condition is now generally recognized to be a cause of the frequent association of peripheral nerve lesions with the latter condition, it must be considered to be a likely aetiological factor in some of the cases under discussion.

The question can hardly be discussed without reference to Volkmann's ischæmic contracture.

**Some Observations on Volkmann's Contracture.**—There has been considerable renewal of interest in this condition in recent years, especially since the publication of Griffith's Hunterian Lecture on the subject (1940). For some years prior to this the venous obstruction theory of its aetiology was generally held, but now the tendency is to regard the condition as being due to arterial injury and spasm. Recently Albert and Mitchell (1943) put forward the view that the Volkmann syndrome can be caused either by temporary arterial obstruction or by venous occlusion. On the whole the evidence seems to be in favour of Griffith's contention that the true Volkmann's ischæmia with massive necrosis of muscle-fibres and their subsequent replacement by fibrous tissue is due to deprivation of arterial blood-supply generally as a result of traumatic arterial spasm. Nevertheless there is little doubt that a form of muscle contracture clinically resembling the true Volkmann type, though probably without the typical histological picture, can occur from venous or capillary occlusion.

The condition occurs most frequently in the flexor muscles of the forearm, usually following supracondylar fracture of the humerus. It is perhaps unfortunate that attention has been so focused on this region that it is probable the condition has frequently passed unrecognized in other muscle groups. Yet there is no reason it should not be found elsewhere, and, in fact, a number of cases have been described.

It is perhaps not without interest that of the 15 cases of nerve lesions described above, 5 show fairly definite evidence of Volkmann's necrosis, and in none of these is it in the forearm. The distribution is as follows: Flexor hallucis longus (Case 6), Anterior tibial group (Case 9), Biceps brachii (Case 10), Triceps (Case 11), and Interossei of the hand (Case 13). In all these five cases there was direct or indirect evidence of arterial injury, and the question arises as to what determines the site of the subsequent muscle necrosis. The effect of a main arterial lesion on the limb depends largely on the condition of the collateral circulation. To quote Griffiths (1940): "If this be free, all is well. If it be blocked completely, gangrene results. If blockage be incomplete, but too severe or too prolonged for



complete recovery of the limb, then necrosis will occur in the tissues whose vascular demands are highest." There would seem to be three main factors causing obstruction of the collateral circulation—spasm of collaterals by local sympathetic reflexes, thrombosis, and obstruction by swelling, with or without external constriction—and these, as well as the situation of the arterial lesion will determine which muscles will be affected. In the most usual type of true Volkmann's contracture affecting the forearm flexors, the more distal muscles of the limb, e.g., the intrinsic muscles of the hand, are not necessarily affected. It may be that these muscles are more resistant to ischaemia owing to their small size, but it is more likely that the occurrence of necrosis in the forearm flexor group is determined by extension of the arterial spasm (or thrombosis) to involve the actual muscular branches of the vessel, thus isolating the muscles which they supply from any collateral circulation which may be present in the limb and causing massive necrosis. If this be so it would afford a satisfactory explanation of the confinement of necrosis to the individual muscles or groups of muscles in the five cases in our present series.

#### Effect of Arterial Lesions on Nerves.—

Though nerve lesions are well known to be frequently associated with Volkmann's ischaemic contracture, they have generally been considered to be due to coincident direct injury to the nerves or to subsequent involvement of the nerve-trunks in the fibrosis which inevitably follows and is, in fact, part of this condition. It seems, however, that many reported cases of Volkmann's contracture have had no nerve lesions at all, so that it would seem to be possible for arterial injury and associated spasm to cause necrosis of muscle without at the same time rendering the nerve-trunks sufficiently ischaemic to cause peripheral degeneration or even temporarily to abolish conduction in them.

It is well known that the principle artery of a limb can be ligated without, in most cases, causing any permanent damage to either muscle or nerve. If, however, the circulation to the limb is completely arrested, as by a tourniquet at its root, conduction in the nerves distal to the tourniquet begins to fail within half an hour (Bentley and Schlapp, 1943, a). Even after conduction has been abolished in the nerves of the ischaemic limb the muscles will still respond to direct stimulation. That is, in ischaemia the function of the nerves fails before that of the muscles. But, according to Lewis (1936), long-continued ischaemia kills muscle more readily than it kills nerve. The actual times are not known, but Lewis suggests that muscles are killed after six to eight hours of ischaemia while nerves will recover after twelve to twenty-four hours.

This question of the relative susceptibilities of muscle and nerve is obviously important in our present discussion, for if, as seems likely,

muscle is more susceptible than nerve, we should not expect to find degeneration of nerve in a limb which does not also show necrosis in its muscles. The recent work of Bentley and Schlapp (1943, a) led them to conclude that a small but definite blood-supply is essential for the maintenance of conduction in nerve-trunks, while Bulbring and Burn (1939) maintained that conduction can fail when the blood-supply is reduced below a certain level even though the ischaemia of the nerve is not complete. What does *not* seem to have been established is the degree of ischaemia and the length of time it must act before peripheral degeneration of the nerve becomes inevitable.

In an exhaustive review of the anatomical evidence relating to the blood-supply of nerves, Adams (1942) summarizes by saying that this evidence "shows beyond doubt that all nerves receive a blood-supply and that it is derived from regional vessels which contribute, however, to the formation of a longitudinal vascular pathway along the nerve". Writing on the subject of the innervation of these vasa nervorum, he states that the larger branches of the nutrient arteries running in the epineurium and perineurium have a well-developed tunica media composed of smooth muscle-fibres and that non-medullated nerve-fibres (*nervi nervorum*) have been demonstrated in the same situations. Though the significance of these nerves is not known for certain, Sappey (1889) regarded them as being vasomotor in function. If this be so it suggests a possible explanation of the nerve lesions which sometimes occur in cases of traumatic arterial spasm, for the spasm may involve the regional vasa nervorum in the same way as it may involve the muscular branches of the artery. Whether such a mechanism would cause a sufficient degree of ischaemia of the nerve-trunks to produce peripheral degeneration is doubtful unless there be some additional interference with the collateral supply via the longitudinal pathway. Such additional interference might well be supplied by swelling of the limb.

To summarize, the evidence at present available suggests that on the whole it is unlikely that traumatic arterial spasm can *by itself* cause ischaemic degeneration of nerve-trunks without at the same time producing necrosis in the muscles. The only way in which it could do so—and this is purely hypothetical—would be by extension of the local arterial spasm to involve the regional vasa nervorum.

#### 5. EFFECT ON THE NERVE-TRUNKS OF PRESSURE BENEATH THE DEEP FASCIA

The work of Lewis, Pickering, and Rothschild (1931) is of particular interest in this connexion. During the course of a large number of most interesting experiments on nerve ischaemia in the intact human subject, these workers designed a special clamp by means of which the nerve-trunks of the arm could be compressed without greatly affecting the circulation in the rest of the

limb. Using this clamp they found that pressures as low as 60–70 mm. Hg were sufficient to block conduction in the nerve-trunks, and they showed that the block was due to ischæmia. The onset of the anæsthesia so produced was centripetal in type; it commenced about sixteen minutes after the application of the clamp in the tips of the fingers and gradually spread proximally until it eventually involved the whole area distal to the clamp. Moreover, there was some dissociation of sensation; for instance, loss of tactile and joint sense occurred earlier than loss of pain appreciation, and the relative susceptibility of the various types of fibres subserving different forms of sensation was more or less dependent upon their size. The large diameter fast-conducting fibres (A fibres of Gasser) were more susceptible than the small diameter slow-conducting fibres (C fibres of Gasser). About the time the whole hand had become anæsthetic voluntary power was lost in all the intrinsic muscles of the hand, and later paralysis of the forearm muscles followed.

In these experiments the pressure was never maintained for more than an hour and when it was released there was rapid restoration of function in the nerves.

In most of the cases at present under discussion the history of gross swelling of the limb, the mode of onset of anæsthesia, and the fact that those nerves lying outside the deep fascia at the level of the swelling often escaped, suggest that pressure of extravasated blood and fluid exudate beneath the rather unyielding fascial envelope might reproduce much the same conditions as were operative in Lewis's clamp experiment. The actual pressure which can develop beneath the deep fascia in such cases is, so far as I am aware, not known, but 60–70 mm. Hg would seem to be a possibility.

Recently Bentley and Schlapp (1943, b) have investigated the effects of direct pressure applied to a nerve-trunk in the hind limb of the cat. They found that a pressure of 60 mm. Hg was sufficient to render ischæmic a 4-cm. length of nerve-trunk, but that in this case nerve-block was not produced because of diffusion of oxygen from the adjacent vascularized nerve. In view of this it might well be argued that in the present series of cases there would surely be sufficient oxygen available by diffusion from the compressing fluids to maintain conduction in the nerves. One can only conjecture that the combination of the pressure beneath the deep fascia, *plus* the general anoxia of the limb, *plus* possible thrombosis in the veins and capillaries of the nerves—all involving a considerable length of the trunks—is sufficient to abolish conduction. And if such conditions be allowed to persist for a sufficient length of time, probably about 24 hours, it is likely that peripheral degeneration of the nerves would occur.

This 'pressure ischæmia' theory of causation seems most adequately to explain the clinical

findings in most of the cases under consideration. The mode of onset of anæsthesia, the nerve territories involved, the distribution of muscle paralysis, and the dissociation of sensation sometimes observed are all in accordance with the observations of Lewis et al. (1931). It will be noted that in the lower limb cases the long muscles of the hallux are frequently the only leg muscles affected. They receive their nerve-supply at a lower level than the others. The question of dissociation of sensation was subsequently re-investigated by Lewis and Pochin (1937) and has also been fully dealt with by Wortis, Stein, and Jolliffe (1942). The markedly delayed response to pin-prick which was such a noteworthy feature of many of the cases is of special interest. When observed within a few days of injury (as in *Case 15*) it provides a convincing demonstration of the fact that the slow-conducting 'second' pain fibres are relatively resistant to ischæmia. The phenomenon is, however, more frequently observed shortly after sensory recovery first becomes evident during regeneration. It is sometimes observed during the early stages of recovery after nerve suture, but is much more striking following ischæmia. This may be due to fine and poorly myelinated nerve-fibres growing through the ischæmic region of the nerve-trunk more readily than the fibres of larger diameter, or possibly to delayed remyelination of regenerated fibres. Certainly it is found that the phenomenon disappears as sensation to light touch is regained.

This 'pressure ischæmia' theory is not put forward without the realization that there are certain physical problems involved which cannot be adequately dealt with in this paper, e.g., the question of pressure gradients within tissues of such different consistency as nerve and muscle and the effect of this on the relative degrees of ischæmia in each.

However, the most convincing evidence in favour of the theory is provided by two cases, notes on which have kindly been supplied to me by Professor Seddon, of Oxford:—

*Case A.*—Admitted to hospital complaining of weakness and loss of sensation in the right hand.

**PREVIOUS HISTORY.**—Typical history of hæmophilia, the patient having had at various times hæmophilic arthritis of both knees, both ankles, and right elbow; also melæna and severe bleeding after tooth extraction.

**HISTORY.**—Three months prior to admission the patient fell and struck his elbow against a sideboard. Fourteen hours later the soft tissues of the upper forearm began to swell and show bruising. The swelling rapidly increased and for three weeks the forearm and hand were so swollen that little movement was possible. When the swelling subsided the patient noticed weakness and loss of sensation over the whole hand. This had persisted up to the time of admission, except for some return of sensation in the superficial radial distribution.

**EXAMINATION.**—There was a typical claw-hand deformity of combined median and ulnar nerve palsy. Wasting, paralysis, and R.D. were present

# THE BRITISH JOURNAL OF SURGERY

in all intrinsic muscles of the hand, while all the forearm muscles were normal. There was typical sensory loss in ulnar and median areas, except for some sensation to pin-prick on the radial half of the palm. In the superficial radial distribution sensation was diminished but not lost.

**Conclusion:** "Combined median and ulnar palsy with transient lesion of radial. Level of lesion probably lower forearm and probably of the compression type." No evidence of Volkmann's ischæmic contracture."

**RECOVERY.**—Six months after injury there was no change in motor functions, but considerable recovery of sensation to pin-prick in the median area.

Eight months after injury power had returned to the thenar muscles and sensation to pin-prick had recovered in the ulnar area. "Character of pain: Threshold slightly increased. Appreciation slightly delayed."

Twelve months after injury there was practically full power in median intrinsic muscles, but the ulnar intrinsics, though acting, had lagged behind. Sensation had practically recovered, except for residual loss to light touch, in the distal part of the ulnar distribution.

The function of the nerves continued to improve, but even two years after injury there was still some weakness of ulnar intrinsics and some imperfection of the more specialized sensory functions (stereognosis and 2-point discrimination) in the ulnar area.

**Case B.**—Admitted to hospital complaining of weakness and loss of sensation in the left hand.

**PREVIOUS HISTORY.**—Typical history of hæmophilia since early childhood.

**HISTORY.**—Six weeks prior to admission a ladder fell across the left forearm. Twelve hours later the hand and forearm became very swollen, and the hand became numb and useless. When examined later the following points were noted: Radial pulse present; muscles of forearm soft and showing active contraction; paralysis of all intrinsics of hand; sensory loss of the glove type extending proximally as far as the level of the radial styloid.

**EXAMINATION.**—The findings were almost identical with those in the previous case, except that there was complete anæsthesia in the superficial radial distribution.

**RECOVERY.**—Some recovery of sensation was first noticed seven months after injury and slowly progressed in all three nerves.

Eighteen months after the above injury the patient suffered further slight damage to the forearm with recurrence of similar but less severe symptoms of nerve injury.

The main points of interest in these two cases are:—

1. The trivial nature of the injury, which could not conceivably have been directly responsible for the multiple nerve lesions.
2. The lack of any evidence of damage to main arteries.
3. The relation of the development of gross swelling to the onset of loss of function in the nerves.
4. The involvement of three nerve-trunks all lying beneath the deep fascia at the level of the injury while the superficial nerves were unaffected.

5. The manner in which recovery took place indicates that the lesion was situated in the nerve-trunks and was not a primary effect on the peripheral nerve-endings.

A case in which an ilio-psoas hæmatoma affected the femoral nerve has also been described by Seddon in a paper in which he reviews the association of hæmophilia and lesions in the nervous system (Seddon, 1930).

## SUMMARY OF AETIOLOGY

While most of the nerve lesions described in the present series of cases can be most satisfactorily explained by ischæmia of the nerve-trunks due either to traumatic arterial spasm to pressure beneath the deep fascia or to both it must be borne in mind that often the clinical picture of nerve ischæmia is obscured by coincident mechanical injury to one or more nerves.

## DISCUSSION OF INDIVIDUAL CASES

While space does not permit of a full discussion of all the cases, there are a few points which require special mention:—

Cases 1-7 can be regarded as more or less typical of ischæmic nerve lesions due mainly to pressure beneath the deep fascia, though in Case 6 there was evidence of traumatic arterial spasm.

Case 8 is of particular interest, for, although a lesion of the main artery of the limb was known to be present, signs of nerve damage were definitely related to the development of a large collection of blood beneath the deep fascia of the thigh. All the nerves lying within this fascial envelope were affected and the dissociation of sensation is well shown. The small areas of the areas supplied by saphenous, musculospiral, and posterior tibial nerves are of special interest. The sensory loss in the area of the medial cutaneous nerve of the thigh is probably due to division at operation.

Case 9. The sequence of events here is difficult to explain, but in view of the history of pallor and of the definite presence of Volkmann's ischæmic contracture in the anterior tibial muscles, it is almost certain that traumatic arterial spasm was the main factor in the production of the nerve lesions.

Case 10. The presence of Volkmann's contracture in the biceps indicates that traumatic arterial spasm probably played an important part in the aetiology. The presence of a strong profunda brachii pulse can be correlated with the fact that the radial nerve was less affected than the other nerve-trunks.

Cases 11, 12. Though in both these the radial nerve had been severed, the lesions of the median and ulnar nerves were probably ischæmic in origin.

Case 13. The pathology here is interesting and not very clear. A possible explanation of

the contracture in the interossei would be pressure on the radial artery, possibly with spasm extending into the deep palmar arterial arch from which these muscles are supplied. A relatively intact circulation through the ulnar artery and the superficial palmar arch would maintain the nutrition of the more superficial muscles and the digits themselves. The nerve lesions were probably due to pressure ischæmia of the median and ulnar nerves at the wrist.

*Case 14.* The mode of onset of anæsthesia, the retention of voluntary power in all intrinsic muscles, and the type of sensory loss suggest that pressure ischæmia of the nerve-trunks rather than a block by direct pressure on the nerve-fibres was the underlying cause. The median was more severely affected than the ulnar.

*Case 15.* In one respect this was the most interesting of the series. The ischæmia was apparently of such a degree as to cause peripheral degeneration of all median and ulnar fibres supplying the hand, with the exception of the small-diameter 'slow' pain fibres. Even these were blocked for a few days, but conduction in them was soon re-established in superficial radial, median, and ulnar nerves in that order. Presumably recovery of other types of fibres in median and ulnar nerves will have to await regeneration. At present the unpleasant delayed response to pin-prick and firm pressure is most striking. Another point of interest is that at no time was the circulation in the hand much impaired, which supports the view that the confinement of the effects to the peripheral distribution is not due to a circulatory effect on the peripheral nerve-endings. The circumflex nerve has probably suffered direct damage.

### TREATMENT

It will be obvious that once severe ischæmia of nerve-trunks has caused peripheral degeneration of the fibres, little can be done in the way of treatment apart from physiotherapy, splinting, etc. Recovery will be dependent upon the slow process of regeneration. In cases where the diagnosis is in doubt or where the signs of nerve-trunk ischæmia are thought to be due to the involvement of the nerve in scar tissue, exploration may be indicated.

It is reasonable to suppose, however, that in many of these cases peripheral degeneration of the nerves could have been prevented by early recognition of the condition and by appropriate surgical intervention designed to relieve the ischæmia.

The early management of cases of traumatic arterial spasm has been described by Griffiths, Cohen, Trueta, and others. It includes such measures as forcing the collateral circulation by raising the body temperature. Heating of the unaffected limbs, the affected limb being exposed to environmental temperature, has been found especially valuable (Learmonth, 1943). Oxygen therapy by the B.L.B. mask, the injection of

antispasmodics such as papaverine, and arthrovertebral or intrathecal injections of novocain, have all been recommended, but in most cases early exploration of the artery with periarthral stripping and possibly arteriectomy is indicated.

In those cases where the limb is grossly swollen and tense, and where there is anæsthesia commencing in the digits and gradually spreading centripetally, it would seem to be well worth while to relieve tension in the limb by freely incising the deep fascia. Even when the peripheral pulse is present and though it may mean converting a simple into a compound fracture, this procedure would be justified considering how serious and prolonged is the disability resulting from ischæmic nerve lesions such as those described above. The use of the closed-plaster method in the presence of swelling and obvious circulatory disturbance would appear to be particularly dangerous.

### SUMMARY

Fifteen cases are described in which multiple peripheral nerve lesions are considered to be due to traumatic ischæmia of the nerve-trunks.

The aetiology is discussed and the conclusion reached that the nerve ischæmia is due either to traumatic arterial spasm or to gross swelling and pressure beneath the deep fascia.

The relation of traumatic ischæmia of peripheral nerves to Volkmann's ischæmic contracture is discussed and some observations made on the latter condition.

The importance of prophylactic treatment in the early stages is stressed.

**Acknowledgments.**—This paper is based upon a communication read to a meeting of the British Orthopædic Association in May, 1943. My thanks are due to the Editorial Committee of that Association for permission to publish this amplified version, and to Dr. A. Davidson, Chief Medical Officer of the Department of Health for Scotland, and Dr. C. K. Stevenson, Medical Superintendent of the Hospital, for permission to publish the case records.

I wish to offer my sincere thanks to Professor C. F. W. Illingworth and Professor H. J. Seddon for their helpful advice. I am grateful to Professor D. M. Blair for offering the help of the Department of Anatomy, University of Glasgow, and to Dr. P. Bacsich of that Department for preparing the histological specimens and microphotographs.

### REFERENCES

- ADAMS, W. E. (1942), *J. Anat.*, Lond., **76**, 323.  
 ALBERT, M., and MITCHELL, W. R. D. (1943), *Lancet*, **1**, 519.  
 BARNES, J. M., and TRUETA, J. (1942), *Brit. J. Surg.*, **30**, 74.  
 BENTLEY, F. H., and SCHLAPP, W. (1943, a), *J. Physiol.*, **102**, 62.  
 — — — — (1943, b), *Ibid.*, **102**, 72.

- BULBRING, E., and BURN, J. H. (1939), *Ibid.*, 97, 250.  
 CLARK, D., HUGHES, J., and GASSER, H. S. (1935), *Amer. J. Physiol.*, 106, 647.  
 COHEN, S. M. (1941), *Guy's Hosp. Gaz.*, 90, 201.  
 GASSER, H. S. (1934), *Proc. Ass. Res. Nerv. Ment. Dis.*, 15, 35.  
 GRIFFITHS, D. L. (1940), *Brit. J. Surg.*, 28, 239.  
 LEARMONTH, J. R. (1943), *Edin. med. J.*, 50, 140.  
 LEWIS, SIR THOMAS (1936), *Vascular Disorders of the Limbs*. London: Macmillan & Co., Ltd.  
 LEWIS, T., PICKERING, G. W., and ROTHSCHILD, P. (1931), *Heart*, 16, 1.  
 — and POCHIN, E. E. (1937-38), *Clin. Sci.*, 3, 67, 141.  
 SAPPEY, M. P. C. (1889), *Traité d'Anatomie descriptive*, 3, 224.  
 SEDDON, H. J. (1930), *Brain*, 53, 3.  
 THOMPSON, I. M., and KIMBALL, H. S. (1936), *Proc. Soc. exp. Biol., N.Y.*, 34, 601.  
 WORTIS, H., STEIN, M. A., and JOLIFFE, N. (1942), *Arch. intern. Med.*, 69, 222.

## RETAINED INTRAVENTRICULAR FOREIGN BODY

By J. M. SMALL, MAJOR, R.A.M.C.

THE case presented is one of a retained revolver bullet within the left lateral ventricle following a left frontal penetrating injury. There are but few recorded cases of this type, and for this reason it has been thought justifiable to put on record this case history.

### CASE REPORT

A 29-year-old officer received the following injury at about 5 p.m. on March 1, 1944: a 0.35 calibre pistol bullet entered through the left side of the hard palate, traversing the maxilla, maxillary antrum, the anterior portion of the left orbit, the

On March 3, 1944, he was transferred to a military hospital for head injuries. At that time his only complaint was of headache and this of mild degree. He was fully conscious, rational, and perfectly orientated for time and place.

The left eyelids were oedematous and bruised; the dressing removed from this eye showed a small amount of pulped brain tissue on its surface. Fluid was escaping from between the eyelids, and this was possibly cerebrospinal fluid, but the swelling and tenderness of the eyelids was such that the eye could not be examined at this stage. There was a tender swelling in the left frontal region just anterior to the hairline, but the scalp was intact. In the left side of

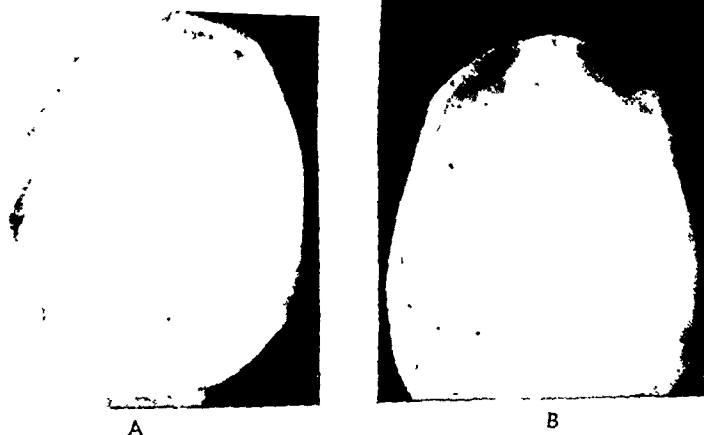


FIG. 345.—Radiographs showing the mobility of the bullet within the frontal lobe before operation; the outward comminution of the frontal bone is well seen in B.

anterior end of the supra-orbital plate, involving the frontal sinus, and then through the left frontal lobe to comminute the left frontal bone without involving the scalp. There was at no time any loss of consciousness, but on admission to a U.S. Naval Hospital at 10 p.m. on the same day he was reported to be rather drowsy, though otherwise to have no abnormal signs in the nervous system. There was no neck rigidity, his temperature was 99°, pulse-rate 62, respirations 22, blood-pressure 130/60. On the morning of March 2 his temperature had risen to 100.6° and lumbar puncture performed at the time showed a slightly blood-stained fluid at a pressure of 85 mm. In the evening his temperature was 100°. From 11 p.m. on March 1 until 9 a.m. on March 3 he received 11 g. of sulphadiazine.

the hard palate was a clot covering a penetrating wound about the size of a sixpenny piece, with marginal pouting of the mucosa and powder staining of the palate in this vicinity. The patient was constantly sniffing, but there was no fluid escaping from the nostrils to suggest a cerebrospinal rhinorrhoea.

General examination was normal, the blood-pressure being now 130/80, temperature 98°, pulse-rate 60, respirations 18. There was no neck stiffness, and the Kernig test was bilaterally negative. The patient was right-handed. Cranial nerves were normal, except for left-sided anosmia. The vision and ocular movements of the left eye could not be ascertained. Power and co-ordination and all aspects of sensation were normal in the limbs. The deep reflexes were normal and equal, plantars bilaterally

downgoing, abdominals diminished on the right side. There was no dysphasia of any type. Mental state: Fully conscious and orientated. Mental arithmetic excellent; 100-7 test, correct in 50 seconds. Digit retention—6 forwards, 5 backwards. Cube test rapidly and correctly done.

Lumbar puncture showed mildly blood-stained fluid under a pressure of 140 mm.; protein 25 mg. per cent, without excess of globulin; R.B.C. 10,100, polymorphonuclears 35, lymphocytes 52 per c.mm. No bacteria were seen on smear and there was no growth on culture. Blood-count: R.B.C. 3,280,000, haemoglobin 82 per cent, W.B.C. 23,600, of which 90 per cent were polymorphs.

Radiographs arriving with the patient showed the bullet lying in the left frontal region, low down on the supra-orbital plate, and a further series of radiographs on admission showed that this bullet had moved forwards and was lying apparently with its tip within the frontal sinus (see Fig. 346); while a submento-vertical picture showed that the bullet was mobile within the frontal lobe and had dropped backwards and medially when the head was in this position (Fig. 345). It also showed an outward comminution of the frontal bone, from which point the bullet must have ricocheted back into the frontal pole. The X rays also showed the track of the bullet, with fracture of the hard palate, dimmed left antrum, and fracture of the orbital floor and the orbital roof, involving the frontal sinus.

He was given 3000 units of A.T.S., and sulphadiazine, 2 g. 4-hourly by mouth, was continued.

OPERATION (11 p.m., March 3, 1944, 54 hours after receipt of the injury).—General anaesthesia—intratracheal gas, oxygen, and ether.

Before operation was commenced, while the patient was under the anaesthetic, the left eye was examined and was found to be completely disorganized, with loss of vitreous. It was quite obvious that evisceration would be necessary. Intravenous plasma and blood being used from the outset, a left frontal scalp flap was turned down, exposing comminuted bone and pericranium, with grossly contused cerebral tissue and clot pushing its way through the fenestrations. The pericranium around this comminuted area was encircled with the cutting diathermy and the lacerated pericranium and comminuted bone fragments were gently lifted away, exposing the traumatized brain protruding through a considerable dural laceration. The pulped brain was sucked away and then covered with a hot pack while bone was nibbled away around the margins of this irregular skull defect, until the dura was seen all the way round, except in the region of the supra-orbital margin, which was also grossly comminuted. Here the fragments of bone were allowed to stay in place because of their proximity to and association with the frontal sinus. A left frontal skull flap including the skull defect was then turned down as an osteoplastic flap hinged on the left temporal muscle, the bone flap going to the middle line. The torn margins of the dural defect were then trimmed and the dura further opened to give a view of the frontal tip right up to the sinus and falx. With this adequate exposure all contused brain tissue was then cleared out of a wedge-like cerebral laceration, the apex of the wedge pointing directly backwards more or less in the centre of the frontal tip. To obtain adequate room to examine the supra-orbital plate and to leave only healthy brain behind, the surgical line of incision was made about  $\frac{1}{2}$  cm. away from the margin of the brain laceration and this fringe of brain removed all round, right down on to

the floor of the anterior fossa, so that only normal healthy brain remained. The floor and supra-orbital part were then inspected and were quite normal, the laceration in the dura only going down to the junction of the vault and frontal base beyond the frontal sinus.

No sign had been seen of the bullet. A good view was obtained right back along the base underneath the frontal lobe, and there was no evidence that it had escaped in that direction. The whole of the brain cavity was then palpated with a brain needle and at

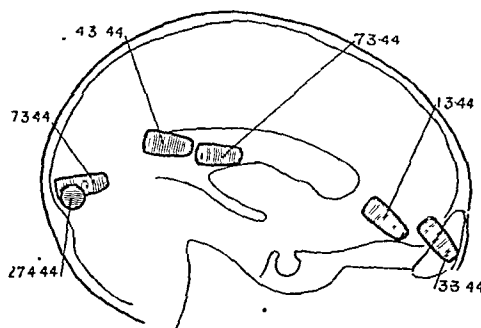


FIG. 346.—Diagram illustrating position of bullet at various dates.

one point leading directly backwards into the frontal lobe the brain needle simply fell in. This was obviously the track and was therefore followed with the sucker and brain retractors for 3-4 cm. The ventricle was never certainly seen, though at one time it seemed likely, because some fluid mixed with blood came up along the track and this may well have been cerebrospinal fluid from the ventricle. A troublesome bleeding-point was encountered at the bottom of this track, and it was felt that it would do more harm than good to search further for the bullet in that direction. It was therefore decided to have the patient X-rayed on the table to see what had happened to the missile; when this had been done it was obvious that the bullet had fallen back through the ventricle and was lying in the occipital horn (Fig. 346, March 4) and that at that time there was nothing to be done about it.

The possibility of turning the patient over and seeing whether the bullet would fall out was considered too precarious a thing to do after the considerable operation that he had already undergone. Four c.c. of 500 units per c.c. penicillin were injected down the brain track and presumably much of this entered the left lateral ventricle. The whole of the dural defect was then trimmed, and a piece of fascia lata sewn into place to close the dura completely. Next, the comminuted bone of the supra-orbital ridge was removed. This laid the frontal sinus wide open; its mucosa was removed and a piece of fascia lata sutured over the apex of the exposed frontal sinus to close it off further. The dura was sutured up all the way round the flap margin to the pericranium and the bone flap was sutured back into position, a gutta-percha drain being led out from the extradural space through the posterior burr hole of the flap and through the posterior limb of the incision. Sulphanilamide powder was added to all layers of the closure, including the brain cavity. The left eye was then eviscerated and the remaining cavity powdered with sulphanilamide and a light pack of vaseline gauze inserted.

At the completion of the operation a lumbar puncture was performed and 4 c.c. of 500 unit per c.c. penicillin were injected into the spinal theca.

The examination of this cerebrospinal fluid showed that it had a protein content of 175 mg., 24,600 R.B.C., 140 polymorphs, and 75 lymphocytes. No

On March 7 screening showed that the bullet was mobile within the ventricle, moving forward from the occipital pole to about the trigone of the ventricle



FIG. 347.—Four days after operation. A (brow-up) shows bullet in occipital horn. B (brow-down) shows that the bullet has moved forward to the region of the trigone of the ventricle.

bacteria were seen on the film and none were grown on culture. Bacteriology of bone fragments removed at the time of the operation showed no bacteria from surface swab and no growth on culture.

Following operation the patient continued to have 2 g. of sulphadiazine 4-hourly until March 8, 1944, 66 g. in all being given. The day after operation he had considerable neck stiffness and a positive Kernig, was drowsy and incontinent, but there was no other discernible change in the physical signs in the nervous system. Lumbar puncture at that time showed a pressure of 160 mm., and the cerebrospinal fluid contained 420 mg. of protein, 14,500 R.B.C., 3100 polymorphs, and 55 lymphocytes. No bacteria on film and no growth on culture. Because of the persistence of neck stiffness and temperature to 100.6°, a further 4000 units of penicillin were given intrathecally by lumbar puncture on March 6, at which time the cerebrospinal fluid protein had fallen to 45 mg. per cent, but its cellular content was still high (7800 R.B.C., 4500 polymorphs, and 62 lymphocytes per c.mm.). Again no bacteria were found on film or culture. From that time on, he made an uninterrupted recovery. He became rather euphoric, but apart from this there seemed to be no evidence of intellectual impairment. The operation wound healed by first intention (Fig. 349). The bullet wound of the palate healed rapidly without any surgical treatment whatsoever, and in the end there was an almost unidentifiable scar in the region of the penetration. No treatment was ever required for the antrum and the orbit healed and granulated satisfactorily.

On March 5, 1944, X-ray screening showed that the bullet remained in the occipital horn of the ventricle.

when the head was put in the brow-down position (Fig. 347). It could not be brought farther forward than this, nor would it go into the temporal

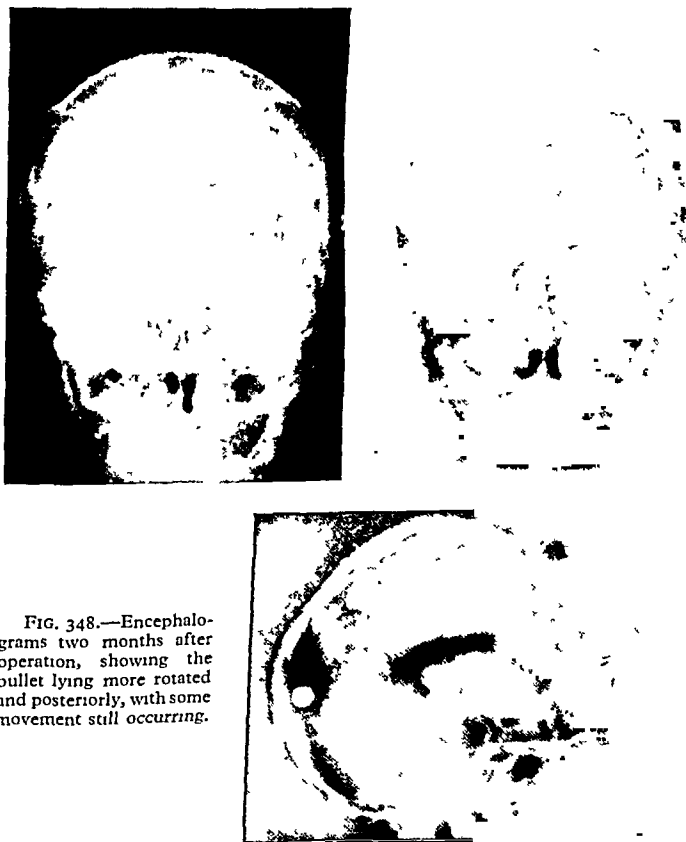


FIG. 348.—Encephalograms two months after operation, showing the bullet lying more rotated and posteriorly, with some movement still occurring.

horn. By March 18 the bullet was in the occipital horn, lying rather transversely and fixed in this position, no movement occurring, whatever the position of the head. Strangely enough, this bullet appeared

to be very far back in the occipital pole, either in a large occipital horn or actually pushing its way out from the ventricle into the occipital lobe proper.

On March 20 screen testing of the right eye showed that there was 6/6 vision and a full field.

By April 26 the X-ray appearances of the bullet were that it was lying even more transversely and farther posteriorly, apparently almost on the occipital bone itself. A cisternal encephalogram performed on April 27 showed that the bullet was lying in the occipital lobe, and although there was some dilatation



FIG. 349.—The patient at the time of encephalography

of the left lateral ventricle in its entirety, with some distortion of the anterior horn, the bullet had apparently left the ventricle itself and there was no visible dilatation of the occipital horn to suggest that it was lying in a prolongation from the ventricle. Slight movements of the bullet within the occipital lobe still appeared to be taking place as judged from the films (Fig. 348). The cerebrospinal fluid taken at this time from the cistern had a protein content of 20 mg. per cent and no cells. Visual acuity remained at 6/6 in the right eye and the field was full and unchanged. On full intellectual testing on May 3, 1944, the patient showed some slight evidence of intellectual impairment and a mild, but definite, euphoric state.

## DISCUSSION

There is a similar case recorded by Campbell, Howard, and Weary (1942), in which a lead buckshot entered the left lateral ventricle in the frontal region and a week after the injury the bullet was shown lying deeply in the left frontal lobe in the middle line. On X-ray examination two weeks later it was seen to be in the occipital lobe. Movements of the head allowed this bullet to roll freely into the frontal lobe and even into the temporal lobe, during which movement no disturbance of any description was noted or complained of by the patient. Two weeks after the initial injury there was a sudden onset of headache, vomiting, and neck stiffness, and there were 210 cells in the cerebrospinal fluid, 65 per cent polymorphs. At this time X rays showed

that the bullet had become fixed in the occipital lobe. This bullet was removed from the occipital horn by an occipital flap without consequent disturbance of speech or visual fields. In spite of pleocytosis the cerebrospinal fluid had always been sterile, and the bullet when it was removed proved to be sterile on culture.

These writers mention another case, of Dandy's, in which it is said that there were such severe symptoms that removal was necessary; but they also mention one other case in which a small roundshot wandered freely from the lateral ventricle to the lower part of the spinal canal without giving rise to any symptoms or discomfort. Geoffrey Jefferson (1918) records a case of movement occurring in a bullet in the cerebellar hemisphere. This bullet moved backwards by 2 cm. towards the occipital bone, and turned round as well, during the course of a few days when it was studied radiologically. On removal it was found to be within a sterile abscess cavity. He also draws attention to the fact that bullets experimentally introduced into the cerebral hemispheres in animals always tend to sink towards the base, and suggests that these movements are due to the high specific gravity of the bullet as compared with brain tissue. He further suggests that movement will be encouraged by surrounding softened brain tissue or abscess formation and pulsation of the brain itself, the rotation which is observed being possibly due to the different weight in different portions of the missile and to the different resistances that it may meet—for example, a portion of it being resisted by a leash of blood-vessels.

The involvement of the ventricle in penetrating wounds of the brain is always of serious significance, and in a review of cases from the last war Cushing (1918) reported 30 cases of ventricular penetration of which only 8 recovered. These 8 were from a series of 14 in which the ventricle had been penetrated by bone fragments and not by the missile itself. All the other 16 cases, in which the projectile either entered or passed through the ventricle, were fatal. Involvement of the ventricle in penetrating wounds has always seemed to carry a mortality of 60 per cent or above, and in some of the recorded series it has been as high as 100 per cent. In this connexion it should be remembered that in the present case prophylactic chemotherapy with penicillin and sulphadiazine was employed.

This case is particularly interesting because the missile was of low velocity and was unlikely to be sterile; even so, after a period of 54 hours its entrance into the ventricle only caused a mild disturbance of cerebrospinal fluid chemistry and cytology. Most other cases recorded have eventually led to removal of the missile because of meningeal infection or irritation. There seems to be no indication for removing the bullet in this case—in fact, there is a definite contra-indication, in that the patient has only one remaining eye, and operative interference would



almost certainly result in a residual field defect and possible speech disturbance.

### SUMMARY

A case is described of ventricular penetration by a revolver bullet which was at first freely mobile within the ventricle and then became lodged within the occipital horn. Spontaneous backward movement and rotation then occurred within the occipital lobe.

I wish to thank Lieut.-Colonel C. W. Greenway, R.A.M.C., for permission to publish this paper, and Brigadier Hugh Cairns for his help in its preparation.

### REFERENCES

- CAMPBELL, E., HOWARD, W. P., and WEARY, W. B. (1942), *Arch. Surg.*, 44, 789.  
CUSHING, H. (1918), *Brit. J. Surg.*, 5, 20.  
HORRAX, G. (1923), *Ibid.*, 10, 19.  
JEFFERSON, G. (1918), *Ibid.*, 5, 19.

## ASEPTIC ANASTOMOSIS IN GASTRECTOMY

By CHARLES A. PANNETT

For many years aseptic anastomosis of the colon has established its place as a sound method of union for this part of the bowel. Its principles

the last three-and-a-half years I have performed gastrojejunal anastomoses exclusively by a one-clamp technique. The advantages have been very great. There is no soiling, the method saves time, no encumbering hæmostatic compression clamps are necessary on the stomach or jejunum, and there is no loss of blood during the actual stitching of the viscera. Nor in all this time has there been a single case of hæmorrhage after operation. The post-operative course appears to have been smoother.

have not often been applied to the joining of the jejunum to the stomach after gastrectomy. The contents of these regions of the alimentary canal having very few organisms in them, there has

The operation is carried out in the following way: The greater and lesser omenta having been separated from the two curvatures of the stomach and the ulcer freed from its adhesions, the duodenum is cut across beyond the ulcer



FIG. 350.—General plan of operation.

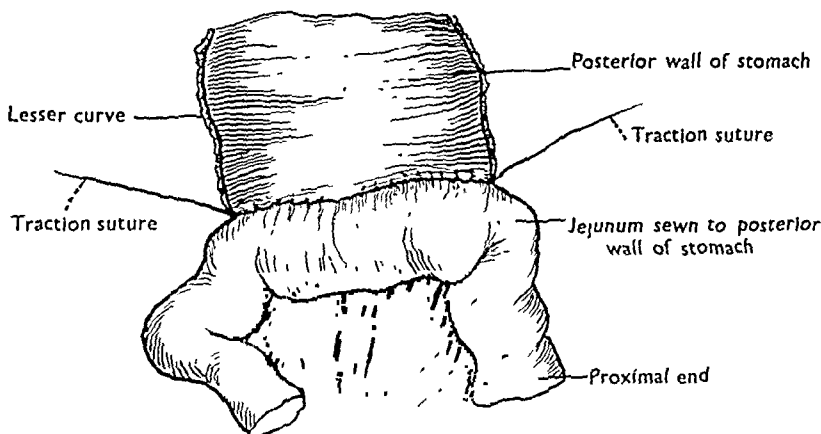


FIG. 351.—First stage of anastomosis. The stomach has been turned over to the left of the patient. Jejunum sutured to posterior wall of stomach by two rows of sutures. View as seen by surgeon standing on right side of patient.

not seemed to be the same urgency for the prevention of soiling with the gastric or jejunal juice. Moreover, the great vascularity of the stomach has aroused fears about the efficacy of hæmostasis in the closed method. However, W. Wayne Babcock (1942) has described the use of an aseptic method of anastomosis. For

if it is in the duodenum itself, or just beyond the pylorus in the case of a gastric ulcer or carcinoma, and the distal end sewn up. The freeing and suturing is carried out according to the methods I have already described. The stomach is then thrown over to the left of the patient and the line of section selected. The first part of the

jejunum is then brought up in front of the colon and at a distance of 5 or 6 in. from the duodeno-jejunal flexure sutured to the stomach just

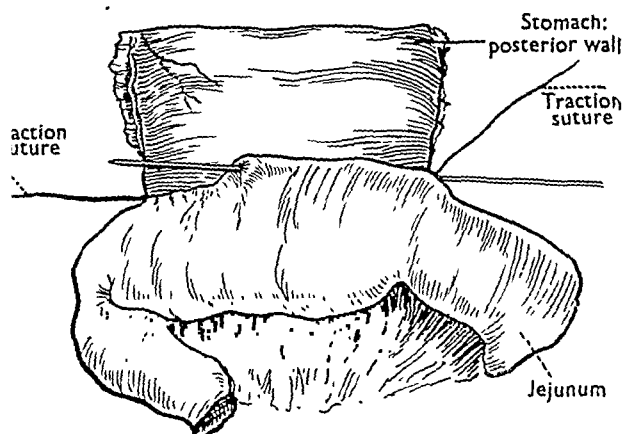


FIG. 352.—The wall of the jejunum has been pulled up in a fold by transfixing it with a wire.

proximal to the selected line with two rows of a continuous thin catgut stitch. The proximal end of the jejunum is at the greater curvature. I have tried interrupted cotton stitches, but all the advantages lie with thin catgut as suture material, used as a continuous stitch (Fig. 351). A pointed wire (a pointed steel knitting needle or a Kirschner wire) is then thrust into the jejunum and out again as depicted in Fig. 352, in order to drag up a fold of jejunal wall. This step is important. Unless this is done it is very easy to pull the muscular coat up away from its loosely attached mucosa and fail to penetrate the lumen of the bowel when the fold in the clamp is burnt off. Two of my duodenal clamps

a little distal to where it has been sewn to the jejunum (Fig. 353). A soiling-prevention gastric clamp is then applied to the stomach distal to the two special duodenal clamps, and the stomach and jejunal fold beyond these latter clamps removed with a cutting diathermy current. A coagulating current is then used to ensure hæmostasis along the cut surface of the tissues in the grasp of the clamps. That clamp on the lesser curvature of the stomach is then loosely oversewn with a continuous suture beginning at the lesser curvature, the clamp removed, and the stitch tightened and carried back as a second row to its beginning. This second row usually passes

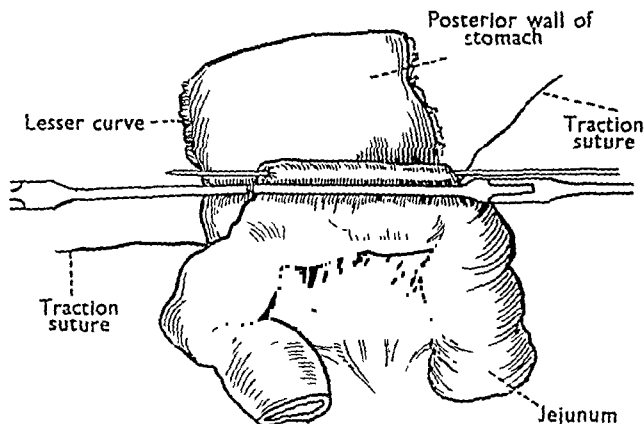


FIG. 353.—The stomach at left, and stomach with jejunal fold at right, have been seized in clamps.

between anterior wall of stomach and jejunum. In this way the upper part of the cut end of the stomach is closed. For reasons I have mentioned elsewhere it is important that the jejunum should

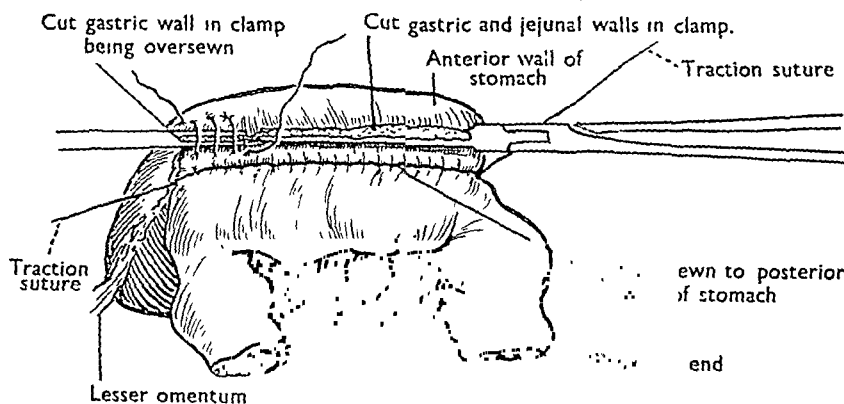


FIG. 354.—The stomach and jejunal fold distal to the clamps have been removed by diathermy cautery. The part of stomach in clamp at lesser curve is being sewn up.

are then taken. Any narrow clamp made so that slipping of the bowel from its grasp is prevented and with blades  $2\frac{1}{2}$  in. long will do. One is made to seize the two walls of the stomach and the fold of jejunum; the other is applied to the remaining part of the stomach between the tip of the first clamp and the lesser curvature

be attached to this part of the stomach (Figs. 354, 355). The anterior wall of the stomach is now sewn to the anterior wall of the jejunum over the clamp which has the four layers of visceral wall in its grasp (Fig. 356). The clamp being removed, the stitch can be pulled tight and the anastomosis effected. In doing this,

to avoid cockling the suture line the two ends of the loose stitch must be held absolutely horizontal. I usually knot the beginning of the

segment of jejunal wall is removed in place of the linear incision in the ordinary anastomosis. Whether it is due to this or to the fact that there

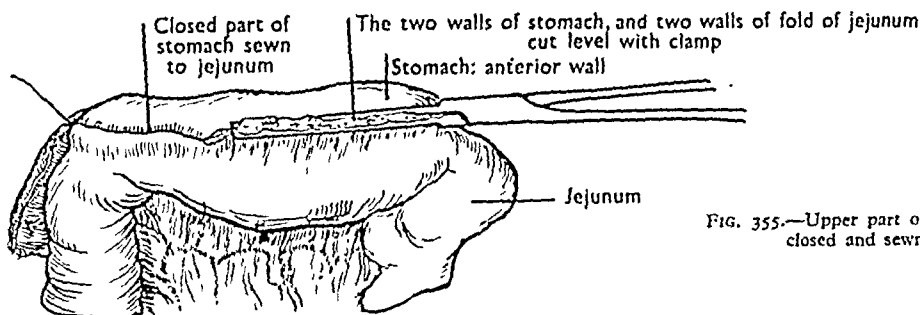


FIG. 355.—Upper part of cut end of stomach closed and sewn to jejunum.

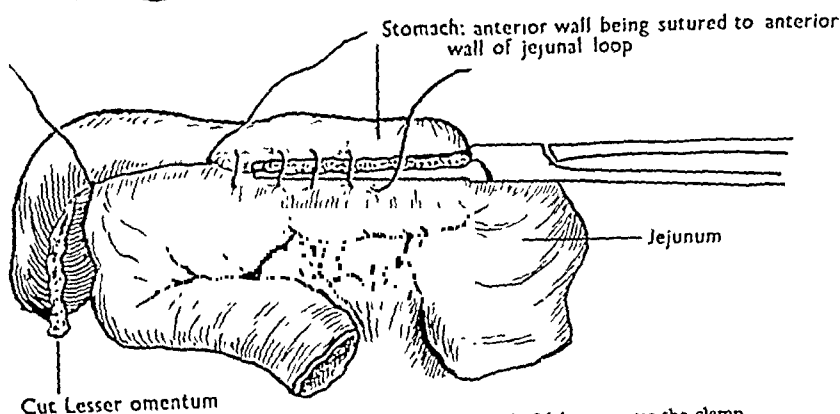


FIG. 356.—Anterior wall of stomach being sewn to anterior wall of jejunum over the clamp.

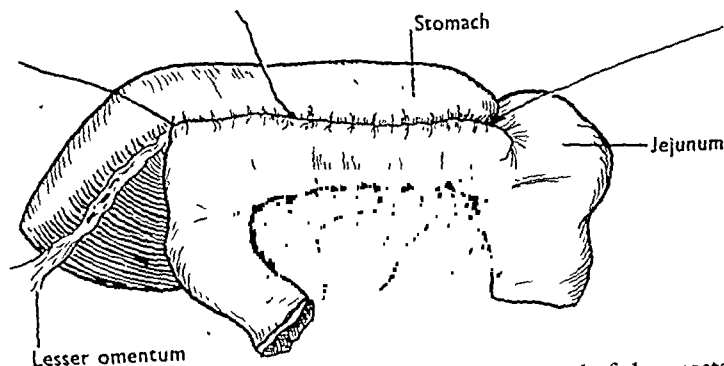


FIG. 357.—Anastomosis completed by additional row of stitches.

stitch at the left as in the figure, and find no difficulty in pulling the suture taut provided the individual mattress stitches are made parallel to the line of junction. The suture is carried back to its beginning to make a second row and complete the junction (Fig. 357). The walls of the viscera immediately separate and form the communication. It may be that the passage of gastric contents is made easy because an oval

is less soiling in the neighbourhood of the anastomosis, convalescence is smoother with this method of union than that usually performed.

#### REFERENCES

- BABCOCK, W. W. (1942), *Surg. Gynec. Obstet.*, **75**, 485.  
 PANNETT, CHARLES A. (1938), *Ibid.*, **67**, 495.  
 — (1924), *Brit. J. Surg.*, **12**, 273.

## RIGHT RETROPERITONEAL DIAPHRAGMATIC HERNIA

By N. R. BARRETT

SURGEON TO OUT-PATIENTS AT ST. THOMAS'S HOSPITAL, LONDON

THE details of this case are presented because the lesion from which the patient suffered is rare and because it raises some interesting points in diagnosis and treatment.

## CASE REPORT

**HISTORY.**—A shopkeeper, aged 52, was admitted to St. Thomas's Hospital in March, 1944.

In December of the previous year he had had an attack of diarrhoea, pains in the lower part of the right chest, and headache. His doctor found no physical signs to account for these symptoms, but there was dullness to percussion and diminished air entry at the back of the right chest. Lobar pneumonia was diagnosed. The patient was kept in bed for three weeks and given a course of sulphonamides, and during this time he was ill and run-down, but had neither cough, sputum, nor pyrexia. He stated that when the time came for him to get up he felt very weak and that he suffered from dyspnoea upon the slightest exertion. During the early months of the year his condition improved considerably, but he was eventually admitted to the hospital complaining of abdominal pain and dyspnoea on exertion.

**ON EXAMINATION.**—The patient was a rather stout man of Russian extraction. His general condition was good; he was afebrile and the pulse and respiratory rates were normal. The only previous illnesses, which he admitted at the time, were an attack of typhus fever 24 years previously, and indigestion for which he had been treated on and off for a long time. The latter had never been very serious, but a diagnosis of duodenal ulcer had been made on several occasions, and radiographs had been taken at other hospitals. The details of these investigations were not available, but neither regulation of his diet nor the use of alkalis had ever had any effect upon the attacks of abdominal pain, and he regarded the 'indigestion' from which he was suffering at the time of his admission as "just another bout of the old trouble".

Physical examination was entirely negative except for signs in the lower part of the right chest which were indicative of a solid mass lying posteriorly at the base of the thorax. The signs also suggested that a thin shelf of lung tissue was interposed between the mass and the chest wall, and a provisional diagnosis of carcinoma of the lung was made.

No sputum was available for examination and the Wassermann reaction was negative. Radiography of the thorax revealed an opacity at the base of the right chest which merged with the shadow of the diaphragm and the liver below, and which had a definite upper edge running transversely across the lower third of the right lung field (Figs. 358, 359). The films indicated that the lesion was probably extrapulmonary in position and a diagnostic pneumothorax was induced to settle this point. The following additional information was provided by subsequent radiographs: the mass was extrapulmonary; it lay at the back of the pleural cavity in close proximity to, but separated from, the chest wall; it was lobulated and showed areas of varying density; the lower edge merged with

the diaphragm and was quite separate from the lung; there was no evidence of calcification (Fig. 360). A follow-through barium meal demonstrated "some deformity of the duodenal cap (which was somewhat higher in the abdomen than usual) considered to be due to adhesions outside the bowel. No evidence of duodenal ulceration was seen".

**DIAGNOSIS.**—The information at our disposal suggested that the differential diagnosis lay between a diaphragmatic hernia, a tumour of the diaphragm, or, possibly, a tumour of the chest wall. The first of these alternatives was rejected because no part of the intestinal canal could be demonstrated by X rays to be abnormally placed. This was not a valid reason for discarding the diagnosis of hernia, because it overlooked the fact that solid viscera can pass into the chest without being accompanied by intestine, and it is a pity that pyelograms were not made.

The second possibility was a tumour of the diaphragm. This term is used in its widest sense to include cysts and granulomata. The condition is rare, and Robson and Collis (1944) state that only 21 examples have been recorded in the literature—in a more recent paper Barrett and Thomas (1944) describe an additional case, in which operation was successfully performed by Mr. C. Price Thomas. The points against such a diagnosis were the size of the lesion, and its position right at the back of the muscle.

Chondroma and chondrosarcoma of the chest wall were ruled out because, both clinically and by X rays, the mass did not lie in continuity with the ribs.

Being at a loss for a definite diagnosis, thoracoscopy might well have been performed, and if this operation had been done it is certain that the lesion would have been considered to be a large lipoma.

The patient was advised to have a thoracotomy, but he was most anxious to avoid operation, and at this point he volunteered the information that he had been wounded in the right chest 26 years previously. This was the first time he had spoken of this injury, and he now admitted that he had been stabbed in the back by a narrow-bladed knife at the time of the Russian Revolution. The injury had not been serious and he had only been confined to bed for a short time; no special treatment had been given and convalescence was uneventful. Upon careful examination of the skin of the back a tiny scar, lying over the 10th rib at a distance of 3 in. from the midline, could still be detected.

**OPERATION.**—Thoracotomy was performed at Horton War Hospital. Dr. M. D. Nosworthy administered a general anaesthetic. Controlled respiration was used, and a blood transfusion was set up as a prophylactic measure.

The chest was opened by the usual intercostal incision and the pleural cavity was free from adhesions. A large mass of lobulated fat was immediately discerned upon the upper aspect of the diaphragm in the position indicated by the X rays. A little dissection revealed that the 'tumour' was a retroperitoneal diaphragmatic hernia containing the right kidney surrounded by the perinephric fat. There was no hernial sac. The aperture in the diaphragm

was about  $3\frac{1}{2}$  in. long and, after the hernia had been reduced, this was repaired in the usual way with two rows of thread sutures. At the conclusion of the operation the chest was closed in layers and the lung

It is interesting to note that although the upper half of the kidney lay in the right pleural cavity neither the suprarenal body nor the duodenum were seen at the operation.



FIGS. 358, 359.—Anteroposterior and lateral radiographs of the chest, taken at the time of the patient's admission to St. Thomas's Hospital.



FIG. 360.—Radiograph taken after induction of a diagnostic artificial pneumothorax, showing the lung to be quite free from the mass.

was re-expanded by aspirating the air in the pleural cavity. Convalescence was uneventful and, at the time of his discharge from the hospital, the patient had no symptoms.

The 'indigestion' from which the patient had suffered for so many years was presumably due to distortion of the duodenum occasioned by the abnormal position of the kidney. Six months after operation he stated that both the indigestion, and the dyspnoea for which he was admitted to the hospital, had been cured.

### COMMENT

Diaphragmatic hernia is a subject which has been dealt with by many writers (Barrett and Wheaton, 1934; Bowen, 1938; Donovan, 1938; Dunhill, 1934; Harrington, 1942; Hedblom, 1925; Morton, 1939) in recent times, but the above case raises several points which are not generally discussed in these papers:—

1. Why is the lesion more common upon the left side of the body than the right? Bradley (1930) states that the proportion of left-sided to right-sided cases is at least 12 to 1, and the size and position of the liver, in the adult, is not sufficient to account for this by itself. The explanation varies according to the type of hernia under consideration.

In cases due to congenital malformations of the diaphragm Hume (1931) states that there is a strong probability that the defect occurs at that time in the growth of the foetus when the mobile parts of the alimentary canal are undergoing spontaneous reduction, from the hernia in the umbilical cord, into the abdominal cavity—that is, at about the eighth week of intra-uterine life, when the embryo is approximately 20–22 mm.

long. (This supposition is supported to some extent by the observation that the majority of the cases have a hernia at birth, and about 75 per cent die before the age of one.) If the development of the diaphragm is normal the pleuro-peritoneal membranes should have formed and closed the pleuroperitoneal canals, on both sides, by the time physiological reduction of the umbilical hernia occurs. The two canals do not, however, close at the same time—that on the right should seal off at the 17-mm. stage and that on the left at the 20-mm.—and, in consequence, there is more than a chance that the process may not be complete on the left side at the critical moment. There are other factors which favour a left-sided lesion; the liver is entirely a right-sided viscus at this stage of development; the stomach has reached its adult position below the diaphragm; and the left lung is considerably smaller than the right, and so it is not only easier for a left-sided hernia to occur, but there is more space in which it can be accommodated. These explanations are also relevant to another group of congenital cases—namely, those which occur through the dome of the diaphragm posterior to the left tendinous trefoil.

Hernia through the œsophageal hiatus is regarded by most authorities as being due in the first instance to a congenital malformation of the aperture (Hume, 1931; Harrington, 1938). This malformation may take the form either of an unduly large gap or of an absence of one of the crura of the diaphragm. Harrington (1938), who believes that such herniæ are congenital, admits that in his large series of cases the average age at which symptoms first occurred was between 50 and 60 and it may be that the real aetiological factor is that mentioned by Allison and Johnstone (1943). These authors point out that in infancy and in old age there is, normally, a discrepancy between the diameter of the œsophagus and the hiatus in the diaphragm, and through this space the stomach is apt to be drawn up into the chest. Hume (1931) expresses the opinion that such herniæ protrude commonly from the mediastinum into the right pleural cavity, and is satisfied that the sac into which the abdominal viscera pass is in reality a remnant of the lesser peritoneal sac, which, in the embryo, extends upwards as far as the hilum of the right lung. My own experience is that left-sided paracœsophageal hernia is the commoner variety, and the simplest explanation of this is that the hiatus lies to the left of the midline, and the stomach and the spleen, which are the usual contents of the hernia, are also disposed on the left side of the abdomen.

The chance of the diaphragm being perforated by traumatic accidents is equal upon the two sides of the body, but the risk of a hernia developing subsequently is greater upon the left than the right because the liver seals the gap with greater certainty than does the stomach, the spleen, or the colon. It is a mistake, however, to imagine that the liver cannot herniate through

a small perforation of the diaphragm. In life it is a pliable viscus and either a small part of it or, in the case of extensive injury, a whole lobe can pass into the right pleural cavity. In the case of diaphragmatic tears due to crush injuries of the lower chest or the abdomen, the risk of hernia is also greater on the left because the liver acts as a buffer which absorbs the bulk of the pressure changes at the moment of crushing and, in consequence, the right diaphragm is not so apt to be ruptured as the left.

2. The case described above occurred as a result of a stiletto wound sustained at the time of the Bolshevik Revolution in Russia. The scar in the skin was very small and it is probable that the original tear in the diaphragm was of similar dimensions, but, at operation, the hole in the muscle measured about  $3\frac{1}{2} \times 2\frac{1}{2}$  in. This simply means that diaphragmatic hernia behaves in a manner comparable to other types of hernia, in that once the process had been initiated there is a tendency for the lesion to become larger and larger. The importance of the matter lies in the fact that many soldiers sustain small penetrating wounds of the diaphragm, and, as neither the signs nor the symptoms of a hernia may be present during the period of convalescence, the lesion often reaches considerable proportions before its presence is suspected. During this war I have done thoracotomies on patients soon after a chest wound has been sustained and on several occasions have observed a tiny unsuspected perforation of the diaphragm. Within a few hours such a perforation is generally sealed off by a small plug of omentum, which may cure the condition, but which is also likely to act as the apex of a hernia (Figs. 361, 362). In other cases serial radiographs have shown that, as time passes, more and more of the abdominal contents are sucked into the pleural cavity, partly on account of the relatively negative pressure therein, and partly because of the piston action of the muscle itself. This sequence of events accounts for the cases in which a large diaphragmatic hernia is discovered for the first time many years after a patient has been wounded, and it follows that any patient whose diaphragm has been traversed by a small missile should be watched as carefully as those whose hernia is diagnosed early. I have seen two patients who sustained 'minor' thoracic wounds in the last war, who had no symptoms at first, but who after a lapse of some years developed abdominal pains which were diagnosed as 'hysterical'. Both were suffering from large diaphragmatic herniæ.

3. The diagnosis of diaphragmatic hernia is generally based upon the X-ray demonstration of some part of the stomach or the intestines in the thorax. The fact that solid viscera, such as the kidney, the liver, or the spleen may be the only ones to pass through, is apt to be overlooked. The normality of a follow-through barium meal does not in fact negative the diagnosis, although it renders it unlikely. Nor is it true to suppose

that the mass of the liver will prevent intestines entering the right pleural cavity. It has been stressed by many authorities that the intestines may occupy any type of right-sided diaphragmatic hernia and I do not doubt that, if the case at

present reported had been allowed to persist, the duodenum would have passed upward into the chest as an hernia 'en glissade'. Duodenal symptoms were already present.

In this connexion one other point may be mentioned. Routine X-ray examinations of the abdomen reveal the fact that the hepatic flexure of the colon may be insinuated in a normal individual between the dome of the right diaphragm and the upper margin of the liver (Figs. 363, 364). In such a case it would be particularly easy for the colon to enter the right pleural cavity if the diaphragm were to be perforated, and I have



FIG. 361.—Radiograph of the lower chest and abdomen of a soldier, wounded on the previous day. A small fragment of metal, which can be seen lying between the first and second lumbar vertebrae, entered the left chest in the axillary region, passed through the lung and the diaphragm, without causing much clinical disturbance, and lodged in the abdomen. Note that the diaphragm appears to be intact at the time this film was taken.



FIG. 362.—Radiograph of the same patient taken two months later and showing that a small omental hernia has occurred. The mass projects through the wound, in the dome of the left diaphragm, into the left pleural cavity. This hernia, which was causing pain, was cured by operation.



Figs. 363, 364.—Anteroposterior and lateral films of the chest and upper abdomen of a woman showing the colon to be lying between the liver and the dome of the right diaphragm. This state of affairs was not causing any trouble, and the patient had been admitted to hospital for a totally different complaint.

information of a patient in whom the hepatic flexure herniated through a right open pneumothorax which occurred as a result of a wound.

4. The most unusual feature of this case is the fact that the right kidney and the perinephric fat migrated upwards into the chest, and although Harrington (1938) says that this may occur in some cases with a congenital deficiency of the posterolateral part of the diaphragm, I have not found it described as a result of trauma on the right side.

#### REFERENCES

ALLISON, P. R., and JOHNSTONE, A. S. (1943), *J. Thorac. Surg.*, 12, 432.

BARRETT, N. R., and THOMAS, D. (1944), *Brit. J. Tuberc.* 38, 47.  
 — and WHEATON, C. E. W. (1934), *Brit. J. Surg.*, 21, 240.  
 BRADLEY, W. N. (1930), *Arch. Pediat.*, 47, 384.  
 BOWEN, A. (1938), *Amer. J. Surg.*, 39, 4.  
 DONOVAN, E. J. (1938), *Ann. Surg.*, 108, 374.  
 DUNHILL, T. (1934), *Brit. J. Surg.*, 22, 475.  
 HARRINGTON, S. W. (1942), *Ann. Surg.*, 115, 705.  
 — (1938), *J. Thorac. Surg.*, 8, 127.  
 HEDBLUM, S. A. (1925), *J. Amer. med. Ass.*, 85, 947.  
 HUME, J. B. (1931), *Brit. J. Surg.*, 19, 527.  
 MORTON, J. J. (1939), *Surg. Gynec. Obstet.*, 68, 257.  
 ROBSON, K., and COLLIS, J. L. (1944), *Brit. J. Tuberc.*, 38, 1.

## EXPERIMENTAL SURGERY

### THE CONTROL OF HOSPITAL INFECTION OF WOUNDS

By ROBERT E. O. WILLIAMS,

BARBARA CLAYTON-COOPER

M.R.C. UNIT, BIRMINGHAM ACCIDENT HOSPITAL

T. W. HOWAT

ASSISTANT SURGEON, BIRMINGHAM ACCIDENT HOSPITAL

AND A. A. MILES

PROFESSOR OF BACTERIOLOGY, UNIVERSITY COLLEGE HOSPITAL MEDICAL SCHOOL, LONDON

THIS survey was undertaken in the light of recent accounts of hospital infection of wounds (Miles et al., 1940; Spooner, 1941) to extend the observations by McKissock, Wright, and Miles (1941) of the effects of a revised dressing technique on the incidence of added hospital infection. As in previous investigations, our survey was made in terms of *Str. pyogenes*, but our observations differ from them in that we have examined wounds and personnel for the presence of *Staph. aureus* as well, and have tried to assess the magnitude of the reservoirs of both these infecting organisms in the environment.

#### METHODS

**Bacteriological.**—Wound swabs were cultivated aerobically and anaerobically on blood-agar, and in cooked-meat medium, which was plated on blood-agar after 2 days and incubated anaerobically. We have found this addition to direct plating to increase the number of swabs from which pathogens are isolated by 7 per cent. Nasal swabs were cultivated aerobically on blood-agar and throat swabs anaerobically on gentian violet blood-agar (Garrod, 1942). We have confined the term *Staph. aureus* to coagulase-positive staphylococci, and *Str. pyogenes* to beta-haemolytic streptococci belonging to Lancefield's group A. All streptococcal strains isolated were typed by Dr. Elizabeth Topley of the Emergency Public Health Laboratory, Oxford, using Griffiths's (1935) method. By this means we

had hoped to demonstrate the spread of infection among throats and wounds, and the addition of new types to wounds already infected with streptococci. But, owing to the diversity and serological irregularity of the strains isolated, it was not possible to make full use of the results obtained.

**General.**—We studied a 28-bedded male ward, used mainly for patients with septic wounds, for a few patients with uninfected wounds, and some with concussion.

Most of the wounds were dressed daily by the Sister and staff-nurses; the dressings were usually carried out in a side room off a corridor leading from the ward. Our study extended from Aug. 12, 1942, to June 2, 1943, divided into three periods: (1) Aug. 12–Oct. 20 (70 days), a control during which no alterations were made in the established ward routine; (2) Oct. 21–Nov. 30 (41 days), during which certain structural alterations were made in the dressing room, and the nursing staff were trained in a new routine, based on that suggested in the *M.R.C. War Memorandum No. 6*. The training was completed by the end of November. (3) Dec. 1–June 2 (184 days)—a test period to observe any changes in the incidence of added infection following the reorganization. During part of this period the test was complicated by the fact that some patients were treated with penicillin.

The comparison of results from a preliminary control period with those from a subsequent



period, as a means of judging the effect of a changed routine, will be valid only if, among other things, the risk, or 'load', of infection in the environment and the concentration of susceptible wounds among the patients is similar.

Accordingly, we have estimated the average daily magnitude of the reservoirs of infection in terms of carriers of *Staph. aureus* and *Str. pyogenes* both in the upper respiratory tract and in wounds. If it is assumed that the susceptibility of the wound to an added *Str. pyogenes* or *Staph. aureus* is constant throughout its history, a simple estimate of the population of wounds at risk during any period may be made by counting the number of occasions upon which added infection could have been observed by our particular method of examination (see below). The variations of susceptibility with wound age are not known, though it is possible that a long-established wound may be more resistant than a recent one. We have not, however, been able to follow enough wounds for the long periods necessary to test the possibility. Most of the patients who acquired an added infection did so during the first three weeks after admission. Since the average stay in the ward of, for example, the patients without streptococcal infection was 4.4 weeks, and only 7 of 71 patients stayed longer than 7 weeks, our results will not be unduly weighted by the contribution to the data of long-established wounds whose resistance may differ grossly from that of more recent wounds; little difference in our results would be made by ignoring patients followed more than 7 weeks.

As a routine we swabbed the nose and throat of all patients, and the wounds of such as had wounds, on the day of admission and subsequently once a week. The noses and throats of the nursing staff were swabbed weekly. We made a limited number of observations on other reservoirs of infection (e.g., air, dust, etc.) during the autumn of 1942.

## DEFINITIONS AND CRITERIA ADOPTED

**Added Infection.**—The term 'added infection' is used in this report to denote a new-appearing infection (i.e., one which appears in the wound subsequent to the patient's admission to the ward), which we believe to result from the introduction of bacteria from the hospital environment. Since we do not know how long an organism latent in the wound at the time of admission might take to develop sufficiently to be recognized on culture, we have required that, before a wound can be considered free from either of the two indicator organisms, two consecutive routine cultures, with at least 5 clear days between them, should be negative. These two negative swabs we term 'qualifying swabs', since any wound so characterized qualified for admission to the group of wounds at risk of infection with *Staph. aureus* or *Str. pyogenes*. It is obvious that every wound

must on admission undergo a qualifying period, and an infecting organism newly appearing in this period, though in fact it may have been added, cannot by definition be considered as such. If a wound loses an infection and yields the two negative qualifying swabs, it is again classed as a wound at risk.

Reference to Fig. 365 will make the definition of the qualifying swab clear. In Example 1 the negative admission swab A is also a qualifying swab, since 5 days elapse before the second swab, which is thus the second qualifying swab. The wound at the third swabbing R<sub>1</sub>—taken 14 days after admission—qualifies as a wound at risk. In Example 2 the admission swab cannot be used as a qualifying swab, since there are only 2 clear days before the weekly routine swab; here the wound is 18 days old at the third swabbing. Thus two qualifying swabs imply at least 7 days' freedom from infection. (Q<sub>1</sub>—Q<sub>2</sub> in Ex. 1; A—Q<sub>2</sub> in Ex. 2).

The added infection rate is expressed as infections per number of wound-weeks at risk, and is calculated as follows. If R<sub>1</sub> (see Fig. 365, Ex. 1) is positive, the rate is 1/1; if R<sub>1</sub> is negative but R<sub>2</sub> positive, it is 1/2, etc. So that for any wound showing added infection, the rate is 1/(a + 1), where *a* is the number of negative swabs observed after the qualifying period. The added infection rate for all wounds at risk is  $n/(\sum a + n)$ , where *n* is the number of added infections observed, and  $\sum a$  the total number of negative from all qualifying wounds.

It should be noted that, as far as streptococcal infections are concerned, qualification is based solely on the absence of *Str. pyogenes*; the presence or absence of *Staph. aureus* is for this purpose immaterial. Similarly, the *Staph. aureus* infection rates are calculated independently of *Str. pyogenes* infection.

**Load of Infection.**—We have assessed the load of infection in the ward in terms of the average daily number of patients carrying *Staph. aureus* or *Str. pyogenes* in the upper respiratory tract or wound.

Swabs being taken, as a rule, at weekly intervals, we have had to make certain assumptions about the persistence of infection and of the carrier state (see Fig. 365). Where a positive swab was followed by a positive with no more than 10 days' interval, the whole of the intervening period was considered positive. Likewise, with two negative swabs, the whole period was considered negative (Ex. 3 and 4). Where a positive was followed by a negative with no more than 10 days' interval, half this interval was considered positive—half a day being counted as one (Ex. 5). If the interval was longer than 10 days, 5 days after a positive swab was the longest period assumed positive (Ex. 6). In no case was a patient assumed to be positive before the day of a positive swab taken during his stay in the ward (Ex. 7). When a positive swab had been received from a wound, persistence of the same

organism on a plaster covering the wound was reckoned as a positive source, since the presence of microbes on the surface of the plaster clearly constitutes a risk to other patients in the ward.

to inspect the wounds at the time of the routine dressing. This arrangement had the disadvantage that whereas, under the old system, the surgeon could see the 20 wounds in half to three-quarters of an hour, under the new he could only inspect 3-5 wounds in this time. The number was increased by having two wounds ready for him at a given time, but no modification can make this routine inspection as simple as that of the preliminary wrapping of the wounds for inspection in sterile towels. Nevertheless, it seems to us that the use of a loose temporary dressing greatly increases the risk of introducing organisms from the skin and bedclothes of the patient.

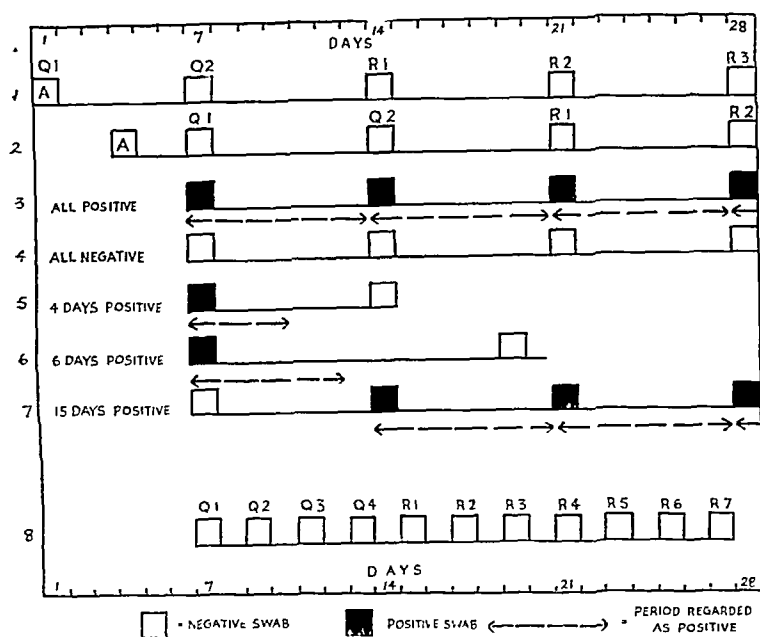


FIG. 365—Hypothetical examples of the results of periodic swabbing, illustrating the definition of 'qualifying' swabs (1, 2, 8) and the method of calculating persistence of the carrier state in the inter-swab periods.

## THE WARD ROUTINE AND ITS REORGANIZATION

During the control period, the dressing routine was, briefly, as follows: The nurse prepared the trolley, uncovered the wound, and then washed her hands. She next performed the wound toilet and rebanded the wound, after which she proceeded directly to the next case without further washing of the hands. During the control period, too, there was a weekly ward round by the surgeon-in-charge, for which the wounds were prepared in advance by removal of dressings and covering with a sterile towel. This was done by a nurse, who uncovered all the wounds in turn, without intermediate washing of the hands or the use of a no-touch technique, and wrapped a sterile towel around them.

There were obviously many opportunities for the introduction of organisms into wounds at the time of maximum risk, i.e., when the wounds were exposed for dressing; the revised technique aimed at the reduction of the opportunities at this time. The revision was based on the recommendations in the *M.R.C. War Memorandum No. 6* (1942), p. 5, and included the wearing of masks, the institution of a rigid no-touch technique, and the exposure of the wound for a minimum time. Instead of several nurses working singly, three nurses worked in a team as server, dresser, and runner. At the same time, the staff stopped the weekly round and arranged

sensibly higher than those from the patients swabbed on admission. It seems probable, therefore, that a small number of patients not

Table I.—CARRIER RATES FOR *Staph. aureus* and *Str. pyogenes* IN THE UPPER RESPIRATORY TRACTS OF PATIENTS AND WARD STAFF

PATIENTS AND STAFF	NO OF PATIENTS AND STAFF	TOTAL NO OF SWABS	PERCENTAGE OF POSITIVE SWABS	
			<i>Staph aureus</i>	<i>Str pyogenes</i>
Patients on admission	447	447	47.5	11.0
Patients during stay in ward	497	1219	56.7	15.8
Nursing staff	56	504	63.3	15.3

carrying the organism at the time of admission tend to become carriers while in the hospital environment (cf. Wright, 1940; de Waal, 1941). Table II shows the average daily number of carriers of *Staph. aureus* and *Str. pyogenes* in the control and test periods, calculated by totalling the number of days of carriage shown by individual patients and dividing by the number of days in the period. The carrier rates indicate the magnitude of the upper respiratory tract sources of infection only if all carriers contribute a similar number of infective particles to the wound environment. The carrier state as determined by the swab depends not only upon the presence or absence

## RESULTS

**Load of Infection: Carriers.**—The average carrier rates for *Staph. aureus* and *Str. pyogenes* in the patients and staff over the whole period are set out in Table I. The rates for the nursing staff and those derived from the weekly swabbing of the whole ward, which included patients who had been in the ward for several weeks, are

# THE BRITISH JOURNAL OF SURGERY

of the organisms, but also on the readiness with which they can be removed from the surfaces of the pharyngeal and the anterior nasal mucosa.

Table II.—SOURCES OF INFECTION IN PATIENTS AND WARD STAFF

SOURCES OF INFECTION	CONTROL PERIOD (70 DAYS)	TEST PERIOD (184 DAYS)
Upper Respiratory Tract (Patients):—		
<i>Staph. aureus</i> , average daily number of carriers	15.0	13.2
<i>Str. pyogenes</i> , average daily number of carriers	2.4	4.3
Upper Respiratory Tract (Staff):—		
<i>Staph. aureus</i> , average daily number of carriers	6.7	6.4
<i>Str. pyogenes</i> , average daily number of carriers	0.9	1.2
Wound (Patients):—		
<i>Staph. aureus</i> , average daily number of carriers	15.2	13.1
<i>Str. pyogenes</i> , average daily number of carriers	6.7	6.5
Wounds (Staff):—		
<i>Staph. aureus</i> , average daily number of carriers	0.2	0
<i>Str. pyogenes</i> , average daily number of carriers	0.2	0

The danger to a wound which the carrier represents, however, is dependent not so much on the carriage of the organism in itself as on the degree to which those organisms are liberated into the environment. The ease with which they may be liberated will be indicated partly by their presence on the swab and partly by the number of organisms isolated. An analysis of the results from nose and throat swabs cultivated in the two periods shows that the carriers were comparable in respect of the number of organisms removed by the routine swab. In most cases the growth of the indicator organisms was either conspicuous or profuse. The proportions of staphylococcal carriers who showed only a scanty growth in the control and test periods were 12.5 per cent and 11.1 per cent respectively. The corresponding figures for streptococcal carriers are 29.0 per cent and 28.5 per cent.

Table III shows the average number of patients in the ward on any one day, in three classes: (a) patients without wounds; (b) patients with wounds, whose stay in the ward was so short that no more than the qualifying swabs could be taken, or patients with wounds which, being infected by both *Staph. aureus* and *Str. pyogenes* on admission, could not be used for the study of added infection; and (c) patients with wounds suitable for the study of added infection.

It will be seen (Table II) that the average daily load of *Staph. aureus* was slightly greater during the control period; that of *Str. pyogenes* greater during the test period. It is noteworthy that this is true both of the staphylococcal wound infections and carriers and of streptococcal carriers; further, the similarity of the nasal staphylococcal carrier rate and the staphylococcal wound infection rate is striking, though its significance as an indication of any immediate

relation between nasal carriage and wound infection is doubtful.

In the control period 17.1 per cent of all the wounds admitted to the ward were available for the study of added infection; in the test period, 26.5 per cent. In the latter period, it will be remembered, a proportion of the patients was being treated with penicillin, and the figures in this table do not distinguish the treated from the untreated patients. If, from the figure for 'available wounds', all those which were at any time treated with penicillin are excluded, the remainder form 17.5 per cent of all the wounds admitted. Penicillin treatment, by rendering some of the wounds sterile, has given us an increased number in which it would be possible to demonstrate added infection.

**Load of Infection: Air and Dust Contamination.**—Using a slit sampler (Bourdillon et al., 1941), we made a small survey of the bacterial flora of the ward air during the whole day. The slit of the sampler was about 5 ft. from the floor, and all the samples were taken on blood-agar plates which were incubated for one day anaerobically, followed by one day aerobically. Total counts for the various times of the day and night, taken on different days, are shown in Fig. 366. There was a large peak during the time of bedmaking and sweeping, but within one hour the count had fallen to a low level, which was maintained throughout the morning. Counts in

Table III.—DISTRIBUTION OF CLASSES OF PATIENT IN THE WARD

CLASSES OF PATIENT	CONTROL PERIOD (70 DAYS)	TEST PERIOD (184 DAYS)
Number of patients admitted to the ward	146	320
Average daily number of patients in ward	25.4	29.4
Patients without wounds:		
Average daily number	3.4	6.9
Average stay in wards in days	6.7	12.0
Patients with wounds, but not included in the survey:		
Average daily number	14.3	12.5
Average stay in ward in days	10.9	14.6
Patients with wounds, included in the survey:		
Average daily number	7.7	10.0
Average stay in ward in days	28.2	32.4
Percentage of patients with wounds included in the survey, of the total number of wounded patients	17.1	26.5

the afternoon were much more variable, probably because there was a fair amount of movement of patients in this period.

During the hours from 9.0 a.m. to noon, when most of the dressing of wounds was done, 17 samples were taken in the ward on different days, with an average yield of 41 colonies per cu. ft. From all these 17 samples of 2 cu. ft., 5 colonies of *Str. pyogenes* were obtained. Fifteen samples taken in one morning, between 9.0 a.m. and noon, in the ward dressing station, yielded an average count of 67 per cu. ft., with a total of 3 colonies of *Str. pyogenes*. *Staph. aureus* was

even less common. At intervals during the same morning as these samples were taken in the dressing station, eight 9-cm. blood-agar plates were left open at bench height for 15 minutes each.

## DISCUSSION

**Added Infection.**—The data presented in Table II show that there was no notable difference in the magnitude of the load of infection present in the ward during the two periods to be compared. The only striking difference in the conditions lies in the greater number of susceptible wounds during the test period, largely, it seems, due to the treatment of a proportion of the wounds with penicillin (Table III). With these facts established it seems justifiable to compare the incidence of added infection in the test and control periods (Table IV). In all groups of patients there was a marked reduction; for example, with the figures for added infection and re-infection with *Str. pyogenes*, the difference is 13.1 per cent ( $SE_d = \pm 3.5$ ,  $d/SE_d = 3.7$ ,  $P = 0.0002$ ). With

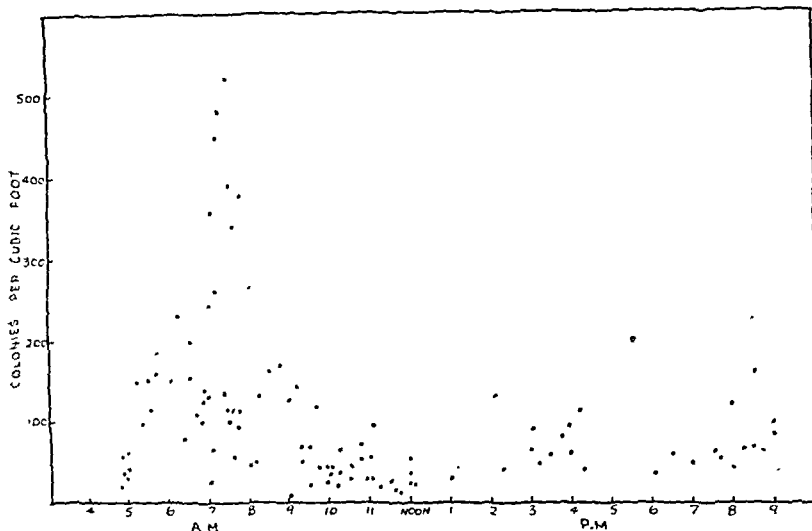


FIG. 366.—Composite diagram of bacterial contamination of ward air; 2 cu. ft. samples at different times of day.

The average number of colonies developing on these was 38, and one plate showed a colony of *Str. pyogenes*. Streptococcal contamination of the air was not, therefore, considerable. It is possible that, had the sampler been nearer the floor, at the level of a wound dressed in bed (i.e., about 30 inches), a greater degree of contamination would have been found, for dust gathered from under the bed of a patient with a streptococcal infection yielded approximately 1,000,000 colonies of *Str. pyogenes* and 400,000 colonies of *Staph. aureus* per gramme. Blood-agar plates exposed under the bed while it was being made, and under the curtains separating the beds, while they were being shaken, also showed several colonies of *Str. pyogenes*.

**Incidence of Added Infection.**—During the control period of 10 weeks, we observed 8 cases of added infection—5 streptococcal and 3 staphylococcal. In the 26 weeks of the test period there were 9 cases in all, 1 streptococcal and 8 staphylococcal. There was thus a reduction in the average weekly incidence from 0.8 to 0.3 cases. These crude rates do not, however, represent the whole picture, for the wounds were at risk for varying times. A truer picture is obtained by calculating the incidence of infection in wound-weeks at risk, as indicated above. Table IV gives the relevant data calculated in this way. The added infection rates are conspicuously lower in the test period, compared with the initial control period. The *Str. pyogenes* rate drops from 13.9 per cent to 0.75 per cent, and the *Staph. aureus* rate from 100 per cent (3/3 cases) to 17.8 per cent.

added infections alone, the difference is 14.7 per cent ( $SE_d = \pm 3.6$ ,  $d/SE_d = 4.1$ ,  $P = < 0.0001$ ). These are differences which might have occurred by chance about twice in 10,000 trials. With staphylococci the reduction in the added infection rate, statistically considered, is highly significant ( $d = 82.2$  per cent,  $SE_d = \pm 25.1$  per cent,  $d/SE_d = 3.3$ ). The comparison is based on the supposition that added infection in each patient is an independent event. If the real incidence of staphylococcal added infection had been the same in both periods, an observed incidence of 3 in 3 cases in the control period might have been attributable to an immediate common cause. However, the 3 cases observed were well separated in time and space and can be considered as independent events.

The greater number of qualified wounds in the test period was due partly to its greater length, but also to the fact that more purely streptococcal infections were admitted, and that a number of the established staphylococcal infections were cleared up by treatment with penicillin, and so qualified for the observation of re-infection; indeed, of the 8 cases of added staphylococci in the test period, 6 were re-infections. In our view, re-infection constitutes less good evidence of added infection than the initial addition of bacteria to wounds that have never yielded these organisms, for it is reasonable to suppose that the probability of an initial contamination lying dormant for 10 days or more is much less than the probability of an established infection disappearing from the parts of the wound available for sampling and lying undetected for a

period in some closed pocket of the healing wound.

In sections 4-9 of Table IV patients treated with penicillin are considered separately from those not so treated, for it might be supposed

cross-infection. The organism was very active in destroying penicillin (Harper, 1943), a fact which may account for the apparent ease with which it colonized these wounds.

#### Limitations of the Method of Bacteriological Survey.

—We might have been able to show even more striking differences between the added infection rates (Table IV) if we had had more patients available for study, particularly in the control period. The duration of this period was limited by circumstances outside our control, but the small number of patients available for the study was also in part dictated by the relatively long period (5-7 days) between consecutive swabs. For example, had we been able to sample every two days, the qualifying period of one week free from infection could have been determined from the results of 4 swabs taken over 8 days. In the case of patients whose ward-life was only 3 weeks, this would have meant that, after the qualifying period of 8 days, there would have been 7 occasions in 13 wound days (R1-R7 in Ex. 8, Fig. 365) for the detection of added infection. As it was, about 7 days were available, in which only one swab was taken.

Some of the wounds yielded streptococci which could be assigned with certainty to one or other of Griffiths's types. In 9 of these wounds which, for a qualifying or longer period, had been consistently infected with one type, a new and serologically unrelated type appeared. There can be little doubt that cross-infection of streptococcal wounds with other streptococci occurred with some frequency, but the total number of wounds yielding typed streptococci was too small to make an estimate of this frequency. It is highly probable that, had a method of subtyping *Staph. aureus*, either serological (Cowan, 1939), or by bacteriophage filtrates (Fisk, 1942), been available, we should have been able to demonstrate similar cross-infection in the staphylococcal wounds.

McKissock, Wright, and Miles (1941) reported a reduction of added infection from 15.4 per cent to 1.1 per cent. Their rates are of added *Str. pyogenes* infections per number of patients admitted free from *Str. pyogenes*, whereas ours are rates of added infection per wound-weeks at risk, so that a strict comparison is not possible. The comparable figures from our data, i.e., infection rates per patient admitted free from *Staph. aureus* or *Str. pyogenes*, showing a newly

Table IV.—INCIDENCE OF ADDED INFECTION IN THE WOUNDS AT RISK

TYPE OF ADDED INFECTION	No. OF TIMES ADDED SPECIES OBSERVED/ No. OF TIMES WHEN ADDITION MIGHT HAVE BEEN OBSERVED			
	Control Period (70 days)		Test Period (184 days)	
	No.	Per cent*	No.	Per cent*
<b>All patients in ward:—</b>				
1. Added species and reinfections:				
<i>Str. pyogenes</i>	5/36	13.9	1/134	0.75
<i>Staph. aureus</i>	3/3	(100)	8/45	17.8
2. Added species only:				
<i>Str. pyogenes</i>	5/34	14.7	0/103	0
<i>Staph. aureus</i>	2/2	(100)	2/22	9.1
3. Reinfections only:				
<i>Str. pyogenes</i>	0/2	(0)	1/31	3.2
<i>Staph. aureus</i>	1/1	(100)	6/23	26.0
<b>Excluding patients who had penicillin treatment:—</b>				
4. Added species and reinfections:				
<i>Str. pyogenes</i>			0/102	0
<i>Staph. aureus</i>			4/15	26.6
5. Added species only:				
<i>Str. pyogenes</i>			0/90	0
<i>Staph. aureus</i>			1/9	11.1
6. Reinfections only:				
<i>Str. pyogenes</i>			0/12	0
<i>Staph. aureus</i>			3/6	(50)
<b>Penicillin-treated patients:—</b>				
7. Added species and reinfections:				
<i>Str. pyogenes</i>			1/32	3.2
<i>Staph. aureus</i>			4/30	13.3
8. Added species only:				
<i>Str. pyogenes</i>			0/13	0
<i>Staph. aureus</i>			1/13	7.7
9. Reinfections only:				
<i>Str. pyogenes</i>			1/19	5.3
<i>Staph. aureus</i>			3/17	17.6

\* Percentages in brackets are based on less than 10 cases.

that, during treatment with an efficient anti-bacterial agent such as penicillin, the risk of development of an added infection would be reduced. This was not so: half the cases of added and re-infection were observed in patients who were treated with penicillin. There was one case of an added staphylococcus during the course of treatment with the drug, as well as one case of re-infection by this organism. Three patients showed re-infection (one streptococcal and two staphylococcal) soon after the termination of treatment.

Coliform organisms were rare in the wounds studied, with the exception of those treated with penicillin. It is noteworthy that between Jan. 11 and Feb. 23 an organism of the paracolon group was isolated from six different wounds which were under treatment with penicillin and from one which was not so treated. Six of the cases showed this infection within one week, and, since we did not isolate this organism from any other wounds during the survey, it seems likely that we were observing a small epidemic of

appearing organism on any swab after the admission swab, are 70.5 per cent and 23.2 per cent respectively in the control period, and 47.6 per cent and 9.3 per cent in the test period, the reduction being 23.9 per cent for *Staph. aureus* and 13.9 per cent for *Str. pyogenes* (Table V). But in any event the populations of wounds and patients studied are not comparable, for the proportion of open wounds admitted with established infection was much greater in our investigation. On the average there were 14.2 wounds

risk, and one which can be reduced by relatively simple revision of existing aseptic measures.

## SUMMARY AND CONCLUSIONS

1. During a control observation period of 10 weeks, the added-infection rate per wound-week at risk in a surgical ward dealing mainly with septic wounds of the hands was 13.9 per cent for *Str. pyogenes* and 100 per cent for *Staph. aureus*.

2. During a test period of 26 weeks, after the adoption of a revised wound dressing technique, the added-infection rates were 0.75 per cent for *Str. pyogenes* and 17.8 per cent for *Staph. aureus*.

3. The carrier and infection rates for *Str. pyogenes* and *Staph. aureus* in the noses, throats, and wounds of the patients and in the noses and throats of the nursing staff were similar in both periods. The number of wound-weeks at risk was higher in the test than in the control period. The reduction in added infection may therefore with confidence be

attributed to the revision of the dressing technique, which was made in accordance with the principles laid down in the *Medical Research Council War Memorandum No. 6*.

We are indebted to Mr. William Gissane, Clinical Director of the Birmingham Accident Hospital, for his advice and help; to Sister J. M. Taylor for her constant collaboration in the revision of the dressing techniques; and to Dr. Elizabeth Topley for her extensive work in subtyping the streptococci isolated.

## REFERENCES

- BOURDILLON, R. B., LIDWELL, O. M., and THOMAS, J. C. (1941), *J. Hyg., Camb.*, **41**, 197.  
 COWAN, S. T. (1939), *J. Path. Bact.*, **48**, 169.  
 DE WAAL, H. L. (1941), *J. Hyg., Camb.*, **41**, 65.  
 FISK, R. T. (1942), *J. infect. Dis.*, **71**, 161.  
 GARROD, L. P. (1942), *Brit. med. J.*, **1**, 290.  
 GRIFFITHS, F. (1935), *J. Hyg. Camb.*, **35**, 23.  
 HARPER, G. J. (1943), *Lancet*, **2**, 569.  
 MCKISSOCK, W., WRIGHT, JOYCE, and MILES, A. A. (1941), *Brit. med. J.*, **2**, 375.  
*Medical Research Council: War Memo., No. 6—The Prevention of Hospital Infection* (1942). London: H.M.S.O.  
 MILES, A. A., SCHWABACHER, HERTA, CUNLIFFE, A. C., ROSS, J. P., SPOONER, E. T. C., PILCHER, R. S., and WRIGHT, JOYCE (1940), *Brit. med. J.*, **2**, 855, 895.  
 SPOONER, E. T. C. (1941), *J. Hyg., Camb.*, **41**, 320.  
 WRIGHT, JOYCE (1940), *Ibid.*, **40**, 647.

Table V.—TOTAL ADDED INFECTION RATES  
(EXCLUDING RE-INFECTIONS).

(Considering all patients with negative admission swabs who had at least one subsequent swab at no matter what interval.)

	NO. OF CASES		DIFF. (d)	SE <sub>d</sub>	d/SE <sub>d</sub>
	Control	Test			
Total free from <i>Str. pyogenes</i>	56	97			
Added <i>Str. pyogenes</i>	13	9			
Per cent added <i>Str. pyogenes</i>	23.2	9.3	13.9	5.9	2.36
Total free from <i>Staph. aureus</i>	14	42			
Added <i>Staph. aureus</i>	10	20			
Per cent added <i>Staph. aureus</i>	70.5	47.6	23.9	15.4	1.55

infected with *Staph. aureus* and 6.6 with *Str. pyogenes* in the ward on any one day. Thus the large load of infection among the wounds and the small number remaining in which added infection could be demonstrated, greatly diminished the likelihood of a clean-cut diminution like that of McKissock et al.

Nevertheless, the association of a drop in the wound-week infection rate with a revision of the dressing technique is sufficiently striking, and it confirms the conclusions of McKissock, Wright, and Miles that added infection is susceptible of reduction by such a revision. Of the more important changes in technique we may mention the introduction of a rigid no-touch technique, of masking the staff, of a routine wash of the hands after the completion of each dressing, the abolition of temporary dressing with sterile towels for convenience of inspection by the surgeon, and the co-ordination into a single team of three persons who previously had acted individually as separate dressers. It should be noted that the revision of the technique did not include any definite measures for the reduction of air-borne bacteria. It remains to be demonstrated that with small wounds exposed to the air for short periods during dressing the risk of air-borne infection is large enough to demand elaborate precautionary measures. Air-borne infection doubtless occurs, but the contact infections, both immediate and remote, constitute a much greater

## In Memoriam

**ERNEST WILLIAM HEY GROVES**

(1872—1944)

HEY GROVES was largely responsible for the foundation of the BRITISH JOURNAL OF SURGERY. He was its first Editor: he continued to edit it with tireless devotion until his retirement in 1941.



*From the painting by Moussa Ayoub in the possession of Mrs. Hey Groves.*

ERNEST WILLIAM HEY GROVES  
Editor of the "British Journal of Surgery"  
1913—1941

An appreciation of his work and service appeared in Number 114, Volume XXIX, of the JOURNAL.

Hey Groves earned and received many honours, but he built for himself his best monument in the BRITISH JOURNAL OF SURGERY, where his services are gladly and thankfully remembered.

## SHORT NOTES OF RARE OR OBSCURE CASES

## A CURIOUS CASE OF AIR EMBOLISM

By P. R. EVANS, MAJOR, R.A.M.C. AND R. S. MURLEY, CAPTAIN, R.A.M.C.

## CASE REPORT

THE patient in this unhappy case was an officer, aged 21, in an Armoured Regiment. While north of the river Sangro in Italy, at 09.00 hr. on Nov. 28, 1943, he was wounded by a shell fragment which entered the left side of his face. The regimental medical officer noted a hæmatoma of the cheek with free bleeding. He could locate no bleeding vessel, but managed to control the hæmorrhage with a skin suture and a firm dressing. The patient's pulse was weak and he was evacuated to an advanced dressing station where the suture was removed and the wound redressed. He arrived at the main dressing station in poor shape and severely shocked, was given 1080 c.c. of blood by a Field Transfusion Unit (F.T.U.), and evacuated to a Casualty Clearing Station (C.C.S.). Here he spent the next two nights and received a further 1080 c.c. of blood from a second F.T.U.

He was transferred to the Advanced Section of No. 1 Maxillo-facial Unit at another C.C.S. on Nov. 30. On admission, at 15.00 hr., he was in fair condition, T. 100.2°, P. 148, B.P. 140/80. At this time several instances had occurred of men developing severe malaria two or three days after wounding, and in view of this patient's fever, a blood-film was taken to exclude malaria. This film was negative and the spleen was not palpable.

There was a wound of the left infra-orbital region, approximately  $\frac{1}{2}$  in. in diameter and situated  $\frac{1}{2}$  in. to the left of the base of the ala nasi. The wound was crusted over with clot and there was moderate swelling of the cheek and left side of the neck, with bruising of the eyelids, subconjunctival hæmorrhage, and infra-orbital anæsthesia. He was completely blind in the left eye.

A radiograph showed a comminuted fracture of the left maxillo-malar compound and a large metallic foreign body in relation to the transverse processes of the atlas and axis on the left side.

The surgeon decided to undertake wound toilet. At 18.00 hr. a sister was about to inject alopon and scopolamine premedication. Immediately the needle pierced the skin the patient tried to climb off his stretcher and said "I want to go home." His temperature was taken again and found to be 102.6°. At 19.00 hrs. he was seen by the physician. The temperature was 104° and the patient was semi-conscious. Quinine dihydrochloride gr. 10 was injected intravenously. A second blood-film showed malignant tertian rings in fairly large numbers. Atebrin musonate g. 0.3 was given intramuscularly.

Next morning the patient was conscious, although not quite rational, and his speech was slurred and hesitant; T. 101.2°, P. 110. He was seen by Major E. C. Zorab, R.A.M.C., eye specialist of No. 2 Mobile Ophthalmic Unit, who found no perception of light in the left eye but clear media, a perfectly normal fundus, and a non-reacting pupil. He suggested that there was some interruption of the optic nerve due to hæmorrhage or compression by a bone splinter or, just possibly, due to a malarial lesion. An oral course of quinine, gr. 10 t.d.s., was started.

During the next two days the patient improved. The temperature oscillated between 100° and 102°.

VOL. XXXII.—NO. 127

but had a downward trend and he felt better and was rational. On Dec. 3 he felt quite well when seen by the surgeon at 09.00 hr. The physician, arriving an hour later, found him feeling well. He complained of some sort of sensation in his left cheek, but his speech was still slurred and it was impossible to make out what he was saying. His breathing was rather 'bubbly.' He was stated by the patient in the adjoining bed to have been quite all right for the next ten minutes. Then he tried to cough up some sputum without much success. At 10.20 hr. he was unconscious and acutely dyspnoic. Ten minutes later he died, clear froth running out of his mouth terminally.

AT AUTOPSY.—The missile had passed from the wound in the left cheek through the antrum and posterolateral antral wall, maxillary tuberosity, pterygoid laminae, pterygoid muscles, and divisions of the mandibular nerve and internal maxillary artery. It had fractured the styloid process and torn the upper part of the internal jugular vein in its lateral aspect, finally lodging in the rectus capitis lateralis muscle of the left side. Bleeding must have been controlled only when the tension in the track became high because blood had tracked extensively among the structures of the left side of the neck. Possibly the blindness of the left eye was due to pressure of blood which had tracked up from the region of the pterygo-maxillary fissure, but no convincing evidence of this was found. The eye and orbit were dissected by Major Zorab, who found no abnormality apart from a large subconjunctival hæmorrhage. The riddle of the blind eye was unsolved.

Subcutaneous emphysema and distension of the superficial veins were noticeable on the upper part of the right anterior chest wall. There was emphysema of the anterior mediastinum and the lung roots, and less marked emphysema of the lower part of the neck. The lungs exhibited acute alveolar emphysema and extensive interstitial emphysema with venous congestion and œdema posteriorly. Large bubbles of blood, as well as small bubbles of air in œdema fluid, could easily be expressed from the cut surface of the lungs. Before the heart was opened the azygos vein was accidentally divided and air bubbles were seen to escape from it.

The outside of the heart appeared normal. The right auricle was opened before the venæ cavæ had been divided and was found to contain only bubbles of blood and no clot, as did also the right ventricle and the pulmonary artery and its divisions. The left auricle and ventricle contained post-mortem thrombus and blood without bubbles.

The spleen was enlarged and congested. A smear from it revealed moderate numbers of *Pl. falciparum* rings.

Comment.—This patient had a severe wound needing specialized treatment. He ran into three dangers in his passage to the appropriate medical unit. The first, hæmorrhage, was controlled by the regimental medical officer. The second, shock, was dealt with by two blood transfusions and staging in several units. He



then reached the Advanced Section of the specialist unit at a C.C.S. and encountered the third hazard, 'post-traumatic' malaria. This was controlled by immediate treatment with quinine and all seemed favourable for evacuation to the base section of the Maxillo-facial Unit for definitive treatment when he died, five days after being wounded, of a freak accident.

Autopsy prevented the death being written off as due to a complication of severe malaria and one is left to conjecture how this man did die.

The cheek wound was sealed with firm clot and there was no tear in the pharynx. Air must have entered the wound track via the nose and maxillary antrum. He had been warned not to blow his nose and was not seen by the other patient in the ward to do so. Presumably the clot softened and the air-track communicated with the tear in the internal jugular vein. He was sitting propped up in bed, the 'thoracic pump' produced a negative pressure in the vein and air was sucked in. This produced first a sensation in the cheek and later respiratory distress as the air filled the right heart and pulmonary arteries. Pulmonary oedema developed and aggravated the distress. Overbreathing

into the reduced alveolar space stretched the alveoli and ruptured some of them, and air then escaped into the interstitial tissue and tracked into the mediastinum, up to the neck and over the chest wall.

Could anything have been done to save this patient? An operation which included discovering and treating the jugular vein tear would have been difficult, prolonged, and probably fatal, for as soon as he recovered from shock he developed severe malaria which was controlled but not cured when he died.

One must wonder, however, whether the pressure in the jugular vein would have been positive instead of negative, causing hæmorrhage instead of air aspiration, if he had been lying flat on the morning of Dec. 3, instead of being propped up in a sitting position because he was so much better and more comfortable that way.

### SUMMARY

An officer received a facial wound involving the maxillary antrum and internal jugular vein. Having survived hæmorrhage, shock, and cerebral malaria, he died of air embolism on the sixth day.

## DUODENAL DIVERTICULUM SECONDARY TO A GASTRIC ULCER

By R. MILNES WALKER

ROYAL HOSPITAL, WOLVERHAMPTON

EXAMPLES of ulcer diverticulum of the duodenum are not infrequent, and their mode of formation is quite clear; they are formed, as has been demonstrated by Edwards (1939), by the contraction of bands of scar tissue in the wall of the duodenum, and the diverticulum is the consequence of a bulge of the wall between such bands. Similar ulcer diverticula have been recorded in the stomach secondary to gastric ulcer. The present case is recorded as it demonstrates the odd occurrence of a diverticulum of the duodenum resulting from scarring associated with a large gastric ulcer which gave rise to scar tissue involving not only the pylorus but spreading across the wall of the duodenum to a sufficient extent to bring about the circumstances suitable for the development of a diverticulum. Mr. Harold Edwards tells me that he has not previously come across this state of affairs, but that he has met with an example of the reverse, viz., a gastric diverticulum secondary to a duodenal ulcer.

### CASE REPORT

Alfred B., aged 51, was admitted to The Royal Hospital, Wolverhampton, under the care of Dr. J. H. Sheldon, on Dec. 18, 1941; he gave a history of gastric symptoms for the previous fifteen years, and medical treatment had never given more than temporary relief. Radiographic examination in 1933

had shown an excavating ulcer on the lesser curvature, while at a recent examination he was reported as

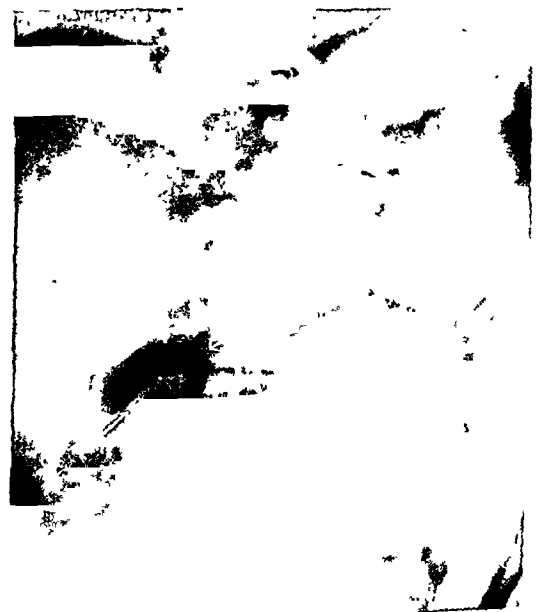


FIG. 367.—Radiograph after a barium meal showing the duodenal diverticulum.

# RUPTURE OF A CONGENITAL DISCOID CARTILAGE 435

having a dilated stomach with considerable four-hour residue; subsequent examination of the plates (Fig. 367) showed the presence of the diverticulum, but this had not been recognized before the operation. No tumour was palpable.

A partial gastrectomy of the Polya type was undertaken on Dec. 23; a gastric ulcer involving the lesser curvature and posterior surface was dissected off the pancreas leaving the base of the crater on the pancreas; the presence of a large diverticulum on

pyloric opening is reduced to a firm ring, with an aperture only 1.4 cm.  $\times$  0.4 cm. Immediately distal to the pylorus, on the lower margin of the duodenum is a diverticulum 2.5 cm. deep, and 1.5 cm. wide at its neck; the widest diameter is slightly greater than that of the neck.

There is no sign of any scarring of the mucous membrane of the duodenum, and the lines of scar tissue seen on the external surface and corresponding folds of mucous membrane, which define the margins



FIG. 368.—The resected portion of stomach from the anterior aspect.

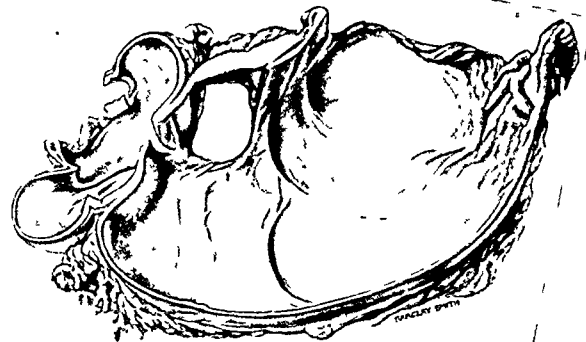


FIG. 369.—The same specimen laid open. Most of the floor of the crater of the ulcer was formed by the pancreas, and is represented by the hole in the posterior wall of the specimen. The pylorus is reduced to a narrow slit. The duodenum has been cut across 1 cm. distal to the diverticulum.

the inferior margin of the first part of the duodenum was noticed as soon as that organ was examined, and care was taken to include this in the portion resected. The patient made a satisfactory recovery, and when seen 2 years and 2 months after the operation stated that he was in the best of health, and had had no gastric symptoms since his operation.

The specimen (Figs. 368, 369) consists of the lower half of the stomach, the pylorus, and about 3 cm. of the duodenum. On the lesser curvature of the stomach is a saddle-shaped ulcer, 4.5 cm.  $\times$  3.2 cm., extending rather farther across the posterior surface than the anterior; the posterior part is represented by a defect in the whole thickness of the wall of the stomach, 2.5 cm.  $\times$  1.9 cm., where the pancreas had formed the base of the ulcer. The

of the neck of the diverticulum, radiate from the gastric ulcer and extend right across the pylorus. It can be assumed, therefore, that in the absence of any evidence of an active or healed duodenal ulcer, this unusually large duodenal diverticulum is the sequel to a chronic gastric ulcer.

I am indebted to Miss Barclay-Smith for the clear drawings of the stomach.

## REFERENCE

EDWARDS, HAROLD (1939), *Diverticula and Diverticulosis of the Intestines*. Bristol: John Wright.

## A CASE OF RUPTURE OF A CONGENITAL DISCOID CARTILAGE

By J. R. BELCHER, FLIGHT-LIEUTENANT, R.A.F.V.R.

THE following case seems worth reporting, as it was possible, pre-operatively, to demonstrate a tear in a congenital discoid cartilage by radiological means, following the technique recently described in this JOURNAL by Cullen and Chance (1943).

### CASE HISTORY

HISTORY.—An airman, aged 19, reported sick with a painful left knee following a severe twist, the force being that of internal rotation of the tibia on the

femur, sustained a few days before. On questioning, he stated that he had had an abnormal left knee, which gave a loud click on flexion after full extension, as long as he could remember, but which had given little trouble apart from occasional pain after prolonged exercise, and which had sustained no trauma that could account for this abnormality.

Since the recent accident the knee had been painful and swollen, and he had been unable to run and walked with a limp. When first seen a diagnosis of a congenitally abnormal cartilage was made, and symptoms were thought to be due to an aggravation

of his normal ache after exercise. However, it was not until fourteen days later, when the pain and effusion showed no signs of receding despite treatment, that the possibility of a tear was considered.

**ON EXAMINATION.**—The quadriceps showed little or no wasting. There was a mild degree of synovial effusion. Tenderness was present over the anterolateral compartment and posterior aspect of the joint, and there was pain on internal rotation.



FIG. 370.—Showing the normal medial meniscus.

On flexion after full extension there was a loud click when the knee was at approximately  $90^\circ$ ; the tibia shook on the femur, and the cartilage could easily be felt coming outwards just in front of the collateral ligament.

Arthrography was performed, following the technique already mentioned, but only about 50 c.c. of air could be introduced without producing a marked degree of tension; the whole joint was firmly



FIG. 372.—Showing the upper surface of the meniscus. The arrow marks the site of the upper end of the tear.

bandaged from above downwards to try and ensure visualization of the cartilage. The medial side of the joint showed no abnormality (Fig. 370).

The lateral side showed a picture which we felt justified our making a diagnosis of a tear of a congenital discoid cartilage (Fig. 371).

A line of cleavage (approximately in the centre) could be seen with the major portion of the cartilage extending right across the joint and being apparently detached at its medial border.

In view of this and the fact that there had been considerable disability since the recent accident, it was decided to remove the damaged cartilage.

**AT OPERATION.**—The cartilage was removed through an anterolateral incision; some difficulty

was encountered in detaching it from the centre of the joint, particularly at its anterior end. Figs. 372, 373 show its appearance after removal.

As can be seen, it was a congenital discoid cartilage with a well-marked tear on its inferior surface which extended up and outwards, but which did not extend as far as the upper surface; just behind the tear there was a niche where the cartilage was not attached to the centre of the joint and which no doubt represented



FIG. 371.—Showing the abnormal side. A, A, indicates the line of the tear; B, the shadow of the inner and apparently detached part of the disc.

an attempt at the normal disappearance of the central part of the disc. The lesion is in fact just as was anticipated from the radiograph, the upper and larger shadow representing the main body of the disc and



FIG. 373.—Showing the quadrilateral detached fragment, with the arrow marking its posterior end.

the smaller one the fragment detached from the lower surface. It shows the actual line of cleavage more clearly than the photographs.

**PROGRESS.**—The patient made an uninterrupted recovery. The rate at which the tone and power of his quadriceps returned was very good and he was up and about six days after the operation. He was discharged on the twelfth day with flexion  $10^\circ$  short of normal, full extension, but still a little wasting of the quadriceps.

## COMMENT

Although it was possible to make the diagnosis on clinical grounds with a fair degree of certainty,

the radiograph is of more than academic interest, as it demonstrates the possibilities of the technique in cases where the diagnosis is more doubtful. The reaction in each of the cases so far done has been very slight. The air is rapidly absorbed and the effusion minimal. It seems a justifiable procedure where the diagnosis on clinical grounds is at all open to doubt.

My thanks are due to S/L K. D. F. Morle for his excellent radiographs.

## SUMMARY

1. A case of rupture of a discoid cartilage is presented.

2. Radiographs after injection of air into the joint are shown in which pre-operative diagnosis was possible.

## REFERENCE

CULLEN, C. H., and CHANCE, G. Q. (1943), *Brit. J. Surg.*, **30**, 241.

## REVIEWS AND NOTICES OF BOOKS

**Recent Advances in Anaesthesia and Analgesia** (including Oxygen Therapy). By C. LANGTON HEWER, M.B., B.S. (Lond.), D.A. (Eng.), Senior Anaesthetist, St. Bartholomew's Hospital and St. Andrews' Hospital, Dollis Hill; etc. Fifth edition. 8 x 5½ in. Pp. 343 + viii, with 141 illustrations. 1944. London: J. & A. Churchill Ltd. 18s. net.

It is but a year since the fourth edition of this invaluable book was published, and yet this fresh edition contains a wealth of new material.

The arrangement of the chapters remains the same, and the new work has been introduced with the author's customary skill. An additional chapter on Anaesthetic Charts and Records has been placed at the end of the book and is of great interest to all anaesthetists.

The new work gives additional information on anaesthesia for thymectomy, general analgesia with ethyl chloride and trichlorethylene, intravenous general analgesia with procaine, improved apparatus for controlled respiration, pethidine analgesia in obstetrics, pressure infiltrators, fractional caudal block, and suction for oxygen cylinders.

There are 141 illustrations, of which 21 are new. These give definite assistance to the reader in assimilating such a vast store of knowledge.

This book has become indispensable to specialist anaesthetists, and both author and publishers are to be congratulated on their successful endeavour in presenting us once again with *Recent Advances in Anaesthesia and Analgesia*, in which we find in very fact 'recent advances'.

**The Surgery of Abdominal Trauma.** By GEOFFREY E. PARKER, M.B., B.Ch., F.R.C.S. (Eng.), Surgeon to the French Hospital, London; Surgeon to the Woolwich War Memorial Hospital; Surgeon to the Erith and District Hospital, Kent; Major, R.A.M.C. With a Foreword by Col. J. M. WEDDELL, C.B.E., F.R.C.S. 8 x 5½ in. Pp. 120 + viii, with 10 illustrations. 1944. London: J. & A. Churchill Ltd. 10s. 6d. net.

THE author was Surgeon to the 24th Field Surgical Unit in the forward areas of North Africa and Italy and he dedicates his book to the 46th Division, from which most of his cases were drawn. As Col. Weddell says in his Foreword, "A recovery-rate of 66 per cent is a most creditable record". This in no small measure must be due not only to the author, but to the anaesthetist, Capt. J. B. Wyman R.A.M.C., and

the team-work of nurses and orderlies of the Field Surgical Unit. As the author also states in his Preface, the smooth running of a Field Surgical Unit would not be possible but for the assistance of many Senior Officers, especially the A.D.M.S. and Field Ambulance Commanders, by whom he was relieved of much administrative and military work, which all surgeons agree should be the case.

The book consists of case records of 94 cases of abdominal trauma. "The notes of the cases were written at the time of the receipt of the casualty and on completion of the operative treatment in the theatre". The 'follow up', which necessarily must be incomplete, "has been done with the greatest care, and in Italy, with short lines of communication, it was possible for the Forward Surgeons to get down to Base Hospitals".

It is to be hoped that opportunity will later be given to the author to complete the follow-up. The number of cases, though small, will, however, make a much more valuable record and addition to our knowledge, if fully completed, than a much larger though incompletely recorded series.

It has been cynically said that next to discussing and describing your own successes, it gives to some the greatest pleasure to discuss the other fellow's failures. The curse of many sets of surgical statistics is 'the successful series'. All the cases are wanted—good and bad—those in which an error of judgement has been perpetrated, as well as those in which the diagnosis was marvellous and the executive technique brilliant.

The author of this book has given us honestly and straightforwardly a consecutive series. Errors of commission and omission are not glossed over but stressed, and he should be thanked for placing his knowledge and experience at the service of others.

"Experience is the Child of Thought and Thought is the Child of Action. One cannot learn men from books", and "What is all knowledge, too, but recorded experience". The author must have learned much from the fourteen abdomens he opened unnecessarily on a mistaken diagnosis.

He naturally begins with the diagnosis of an abdominal injury. The severe one offers few difficulties, but he warns us to beware of: (1) Penetrating injuries in the lower thoracic region which may or may not have entered the abdomen; (2) Abdominal parietal wounds in which intra-abdominal lesions occur as the effect of blast; (3) Buttock wounds which may have penetrated the pelvic peritoneum.

Auscultation of an acute abdomen he considers of great importance, but is sure that the presence of

free blood, unlike other fluids, does not produce "a silent abdomen".

He condemns any attempt to elicit shifting dullness; movement of the patient only makes shock worse and provokes hæmorrhage.

Vomiting is usually absent as it only causes more pain and the patient tries to prevent it.

He naturally and properly insists that all cases should be catheterized to help the diagnosis, and operative approach and proctoscopic examination should never be omitted in lower abdominal wounds.

Absence of liver dullness does not carry much weight with him, nor does a pre-operative X-ray examination. "It is the damage they have done and not the fragments themselves which threaten the patient's life".

In cases of great difficulty a pre-operative radiograph showing free gas below the diaphragm might be the determining factor.

He supports the dictum of the late Sir Cuthbert Wallace, viz., to look and see rather than wait and see. The time factor is one of the surgeon's greatest allies.

Like all surgeons who have dealt with abdominal wounds, he prefers to wait until the patient is "warmed up" but not to waste invaluable time in resuscitation; as in the treatment of ruptured peptic ulcer in civil life, secondary shock and serious complications are prevented by quick operation. For this reason it is not clear why neither blood nor plasma "should be given at any point on the line of evacuation where surgery is not immediately available except in those rare cases where it is virtually certain that hæmorrhage is not taking place and the problem is one of uncomplicated shock". The time for operation was always decided by consultation between the surgeon and anæsthetist. The premedication used was *omnupon* (gr. 1), *scopolamine* (gr.  $\frac{1}{100}$ ) one hour before, and *atropine* (gr.  $\frac{1}{100}$ ) half an hour before, operation. The former might in very urgent cases be given intravenously five minutes before induction of the anæsthetic, which was  $C_2E_3$  mixture. The Oxford Vaporizer was also found most useful.

The midline incision was found to be the best whatever the position of the wound. The operative space can always be increased by suitable right-angled extensions to deal with liver, spleen, or kidney lesions.

The entry and exit wounds were always thoroughly inspected from within when the abdomen was opened, any necessary enlargement being made. They were excised after the abdomen was closed. This routine was followed even if the entry was through the buttock; if hæmorrhage is going on it can be temporarily controlled by packing and dealt with later. Naturally intraperitoneal hæmorrhage must first be dealt with.

Sulphadiazine emulsion was freely used for coating suture lines, etc. If packs had to be left in to control hæmorrhage, then it was found that daily moistening with iodine, 1 part, glycerin, 9 parts, made subsequent removal easier.

The peritoneum and fascia were always closed with continuous catgut, a few tension catgut sutures were put into the fascia, but no deep through-and-through skin stitches, the latter took up only the subcutaneous fat. The subfascial planes were always drained by a slip of corrugated rubber. There was only one 'burst abdomen' in the ninety-four cases, and that incision had been closed without drainage.

The technique for the repair of viscera became to some extent standardized, splenectomy for all splenic wounds, nephrectomy for disorganized kidney

and injury to pedicle, but some kidney wounds were sutured. Gunshot wounds of the kidney may be much less painful than kidney injuries in civil life, because in the latter the renal fascia and capsule are not usually ruptured. A word of warning is given urging that the ureter and pelvis of the kidney should always be dissected from the renal pedicle before ligaturing the latter. Risk of recurrent hæmorrhage from the renal artery is thus diminished.

Wounds of the liver, as the result of experience, should be sutured and packed; those on the posterior surface can be explored through a posterior trans-thoracic incision.

Only one in five cases required resection of bowel, the indications for which are: (1) Gross destruction of a length of intestine. (2) Damaged mesentery near to the bowel wall depriving the bowel of its blood-supply. (3) Damaged main junctional vessels in mesentery remote from bowel. (4) Burned bowel. This must be looked for especially if there is no wound of exit and is more common than usually thought to be.

End-to-end anastomosis was used, as it is performed quickly; if there are many perforations a loop of bowel may be marsupialized and dealt with later.

A valvular cæcostomy is usually an essential in colon injuries, but often a colostomy is better. The latter naturally is definitely indicated in rectum injuries and should always be complete.

For bladder injuries a suprapubic cystostomy is better than the indwelling catheter and should be maintained for eight days at least.

The term 'retroperitoneal syndrome' is introduced as a diagnosis in some types of abdominal injury and accredited to Lt.-Col. Jolly. It seems a pity to introduce what may well become a cliché to describe retroperitoneal and pericolic hæmorrhage. The symptoms are all well known and have been recognized for many years by surgeons dealing with 'heavy-industry' and 'run-over' accidents. It is true that these cases cause great anxiety and difficulty to the surgeon, but it is better to be sure than sorry. There is a tendency to dismiss a doubtful case as 'extraperitoneal syndrome' and leave it at that. The condition may also be due to mesenteric thrombosis with no hæmorrhage.

The author must owe a special debt of gratitude to those who carried out the post-operative treatment. In spite of routine duodenal suction, transfusion, free use of chemotherapy, it is the nursing and encouragement given to the patient which plays such an important part.

It will repay any surgeon to study the case records carefully, and to experience the thrill which evidently the author got when he watched the recovery of some of them and also share his disappointments. The outcome of such a series must have been a cause of great satisfaction to the team, all of whom are to be congratulated on being physically fit to carry out such work under such conditions. They must all be:

"By nature honest, by experience wise,  
Healthy by temperance and by exercise."

**Vascular Responses in the Extremities of Man in Health and Disease.** By DAVID I. ABRAMSON, M.D., F.A.C.P. 9 x 6 in. Pp. 412 + x, with 59 illustrations. 1944. Chicago, Ill.: The University of Chicago Press (London: Cambridge University Press). 30s. net.

This volume is the outcome of ten years' study of the literature of the subject, combined with the author's own experience of the many methods he

describes for investigating the peripheral circulation in man. Its particular virtue lies in the detailed account given of the venous occlusion plethysmographic method of estimating blood-flow, which, in spite of many theoretical criticisms, is regarded as the most satisfactory quantitative method at present available. No doubt it would be easier to apply in practice than it seems to be in the written description—for however clear the directions may be, demonstration must be clearer—and it is not fair to judge the method without a trial. But one gains the impression that attention to the many factors which have to be controlled if results are to be reliable makes it a method of physiological and clinical research, rather than a test which can be usefully employed as a routine measure for assessing the peripheral circulation in hospital patients.

Whether this be so or not, the book is of much value as a stimulus to greater accuracy in the examination and recording of peripheral vascular injury and disease, and it will amply repay study by any clinicians interested in this subject. In addition to the physiological control of the circulation, consideration is given to abnormalities produced by disease, to vasodilator and vasoconstrictor drugs, and to the effects of various therapeutic measures, such as sympathectomy. The bibliography shows clearly how much study, thought, and industry have gone to the making of the book.

**The Rehabilitation of the Injured.** Occupational Therapy. By JOHN H. C. COLSON, Technical Director of Rehabilitation, Accident Service, Royal Sheffield Infirmary and Hospital. With a Foreword by E. A. NICOLL, M.D., B.Ch., F.R.C.S. (Edin.).  $8\frac{1}{2} \times 5\frac{1}{2}$  in. Pp. 226 + xvi, with 196 illustrations. 1944. London: Cassell & Co. Ltd. 15s. net.

THE literature of rehabilitation is of two kinds: the generalizations and vapourings of the platform experts; and the much more rare—and welcome—utterances of those who know how to do the job and have the gift of imparting their knowledge to others.

The author of this book is among the latter, and his special field is occupational therapy. Most of this work is technical, and the reviewer is not in a position to pass judgement on the apparatus, materials, and methods of construction that Mr. Colson describes with a wealth of detail and illustration. However, if the technical sections are as sound as the parts of the book that a comparatively unenlightened surgeon can understand—those that deal with the care of the injured patient—then this is a work that can be recommended without a moment's hesitation.

**Textbook of Surgical Treatment**, including Operative Surgery. Edited by C. F. W. ILLINGWORTH, M.D., Ch.M., F.R.C.S.E., Regius Professor of Surgery, University of Glasgow. Second edition.  $9\frac{1}{2} \times 6\frac{1}{2}$  in. Pp. 564 + xii, with 230 illustrations. 1944. Edinburgh: E. & S. Livingstone Ltd. 30s. net.

IN its second edition this book is slightly increased in size and price and considerably improved by a new chapter on the treatment of burns and an addition of nearly 100 illustrations. It presents a series of accounts of the treatment of various surgical conditions written by a number of contributors. Each

chapter is complete in itself and forms a useful guide for the student or surgical trainee in the principles of treatment of the condition discussed; there is in most cases a deliberate omission of such technical details as the operating surgeon would require. Whilst many of the accounts are excellent, there are still some items which we feel should be included in a work of this character, and to which we drew attention in our review of the first edition. Among more recent developments there is no mention of synthetic oestrogens or of castration in the treatment of carcinoma of the prostate. The statement that perineal hypospadias is "unsuitable for treatment" is neither true nor helpful; surely this is the type most in need of treatment.

The chapter on the surgery of the autonomic nervous system remains one of the best in the book, and the new chapter on burns gives good detailed instructions of the methods which have proved most satisfactory in the author's hands.

**Pye's Surgical Handicraft.** Edited by HAMILTON BAILEY, F.R.C.S., Surgeon, Royal Northern Hospital, London; etc. Fourteenth edition, fully revised.  $9 \times 6$  in. Pp. 628 + xi, with 724 illustrations. 1944. Bristol: John Wright & Sons Ltd. 25s. net.

THE issue of the fourteenth edition in its diamond jubilee year is a fitting tribute to the continued popularity of "Pye"; in itself this edition shows several changes when compared with its predecessors, and its utility is enhanced by much new matter which brings it right up to date. Mr. Hamilton Bailey has enrolled such a large number of contributors that the book is now a complete guide to all the duties of the house surgeon. It is arranged for easy reference, and the number of illustrations has been increased; some of the new coloured photographs are rather small, but are adequate for their purpose.

We are surprised to find no mention of the indigo-carmin test of renal function; it is more widely used in this country than the phenol-sulphone-phthalein test which is described. In other respects this chapter is excellent.

The book is one of the most useful which the surgical dresser can possess and is almost an essential for the house surgeon; the new edition can be confidently recommended as a worthy advance on its forerunners.

**Aids to Theatre Technique.** (Nurses' Aid Series.) By MARJORIE HOUGHTON, S.R.N., S.C.M., D.N., Sister Tutor, University College Hospital; and MARGARET HARDING, S.R.C.N., S.R.N., S.C.M., Senior Theatre Sister, University College Hospital. With a Foreword by WALPOLE LEWIN, M.S. (Lond.), F.R.C.S., Capt. R.A.M.C., late Harker Smith Registrar and Assistant to Surgical Unit, University College Hospital.  $6\frac{3}{8} \times 4\frac{1}{2}$  in. Pp. 262 + xiii, with over 100 illustrations. 1944. London: Baillière, Tindall & Cox. 4s.

THIS is one of the *Nurses' Aid Series* which the publishers hope, when completed, will cover "the field of knowledge required from the modern nurse".

From the titles of the volumes already published, it appears that the education for examinations of the student nurse, like that of the medical student, is being directed more and more to the importance and prestige of the science; while the vocation and art of her profession is being submerged beneath a flood

of factual knowledge. In spite of what matrons and sister tutors may think and say, a nurse's profession is surely one to which a woman still may be born, and the nurse whom the examiners reject be a real loss to the community.

The publishers give no indication as to whether they propose to issue an "Aid to the Vocation of Nursing" or "Aids to Matrons, Home Sisters, and Sister Tutors" as a grand finale to the series, "illustrated where necessary".

As is stated in the Foreword, it is impossible to standardize operative procedures by different surgeons (thank goodness!), and herein is one of the theatre nurses' great difficulties. It should be possible, however, to agree on certain basic principles, some of which are not mentioned in the text, e.g., the ward nurse should see that the ward blankets are not taken into the theatre, but replaced by clean bath towelling. This is more important for a successful outcome of the operation than notes, X-ray films, etc., nor is a sick bowl out of place as an accessory, and the warm gown and blanket should be ready to cover the patient when he leaves the theatre rather than "when he returns to the ward".

There is no margin of safety for sterilization of theatre linen, yet the authors seem satisfied that "once a month drum tests are made to ensure that sterilization is efficient". On the other 27 days it may be inefficient, yet chemical tell-tales could be inserted every day and any error in sterilization be detected.

In the chapter on anaesthetics there is no mention that the close liaison with the anaesthetist, who should have examined the patient pre-operatively, is more important than that "between the theatre and the ward". This liaison is all the more necessary as there are many more bad anaesthetists than anaesthetics. It is a pity that the Oxford Vaporizer is not mentioned.

The main part of the book consists of excellent photographs of instruments for various operations,

with explanatory captions, all of which will be of great use to the theatre nurse in the course of her training and after.

Occasionally there is a running commentary which will whet the appetite of any surgeon, e.g., under the heading of abdomino-perineal excision of the rectum it is stated, "Both steps of the operation may be performed simultaneously by two teams". This must be staged only for very special occasions to prevent gate-crashing.

The nurse should be warned that when diathermy is being used all inflammable fluids should be removed from the vicinity of the apparatus. The ophthalmic surgeons should be supplied with local anaesthetics, as also should be done when the instruments are put out—the authors prefer "lay up"—for Rammstedt's operation or thoracotomy.

It is surely a mistake to say that Crutchfield's skull callipers "are inserted *through* the parietal bones" in the treatment of fracture or dislocation of the cervical spine. If the illustration on page 175 is taken during life, then the operator's technique appears to have run away with his reason. The technique of neurosurgery is exceedingly difficult and tedious, but well it may be, if all the instruments illustrated on page 187 are required for ventriculography.

There are a few avoidable misprints, that on the last line but one on page 215, should amuse Sir Harold, and Bonney-Reverain, on page 244, is at first sight almost the truth.

The book, however, does supply a real want amongst nurses. This first edition bears evidence of haste. It will, one is sure, be absent from subsequent editions, which will probably also incorporate many suggestions from theatre sisters all over the Empire.

But however many aids to knowledge may be published, let it always be remembered by the nurse that:

"Knowledge comes, but wisdom lingers."

## BOOK NOTICES

*[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.]*

**Textbook of Anaesthetics.** By R. J. MINNITT, M.D. (Liverp.), D.A., Lecturer in Anaesthesia, University of Liverpool; etc.; and JOHN GILLIES, M.C., M.B., Ch.B. (Edin.), D.A., Consultant in Anaesthetics, Department of Health for Scotland; Anaesthetist, Professorial Surgical Unit, Royal Infirmary, Edinburgh; etc. Sixth edition. 8½ × 5½ in. Pp. 487 + viii, with 199 illustrations. 1944. Edinburgh: E. & S. Livingstone, Ltd. 25s. net.

**Operations of General Surgery.** By THOMAS G. ORR, M.D., Professor of Surgery, University of Kansas School of Medicine, Kansas City, Kansas. 10½ × 7½ in. Pp. 723 + viii, with 1396 illustrations on 570 figures. 1944. Philadelphia and London: W. B. Saunders Co. Ltd. 60s. net.

**The Urinary Tract.** A Handbook of Roentgen Diagnosis. By H. DABNEY KERR, M.D., Professor

of Radiology, State University of Iowa College of Medicine, and CARL L. GILLIES, M.D., Associate Professor of Radiology, State University of Iowa College of Medicine. 8 × 5½ in. Pp. 320, with numerous illustrations. 1944. Chicago: The Year Book Publishers Inc. (London: H. K. Lewis & Co. Ltd.) 34s. net.

**The American Academy of Orthopaedic Surgeons Presents Lectures on Reconstruction Surgery.** Selected from the Instructional Courses of the Twelfth Annual Assembly, Chicago, January 23-24, 1944. Edited by JAMES E. M. THOMSON, M.D., Lincoln, Nebraska, Chairman of the Instructional Section. 10½ × 8½ in. Pp. 568 + iv, with many illustrations. 1944. Ann Arbor, Mich.: Edwards Bros. Inc. (London: H. K. Lewis & Co. Ltd.) £2 9s. net.

# THE BRITISH JOURNAL OF SURGERY

Vol. XXXII

APRIL, 1945

No. 128

## THE INTERNAL INGUINAL RING

BY W. J. LYTLE, SHEFFIELD

THE mystery of the protective mechanism which Nature provides at the place of exit of the spermatic cord has for long exercised the minds of anatomists and surgeons.

Sir Arthur Keith (1923) described a shutter mechanism, whereby the lower fibres of the internal oblique and transversalis muscles become pressed against, and flush with, Poupart's ligament, when the intra-abdominal pressure is raised in such acts as coughing and straining. In this way the internal ring and, especially, the posterior wall of the canal are protected against internal stress. This conception, important as it is, tends to view the internal ring as a fixed opening.

It is the purpose of this paper to show that the internal ring itself has mobility and to describe an active closure mechanism in which the ring, under stress, moves upwards and outwards under cover of the internal oblique and transversalis muscles.

### POSTERIOR WALL OF INGUINAL CANAL VIEWED FROM BEHIND

The operating surgeon knows little of this aspect of the inguinal canal, so well is it hidden from his view. To obtain a full and undistorted picture in the cadaver (*Fig. 374*) the anterior abdominal wall is removed with the bony framework of the pelvis. When the peritoneal and subperitoneal coats are stripped off, the posterior fascia of the abdominal wall, named the fascia transversalis, is exposed.

The internal ring stands out as the pivot around which the transversalis fascia is arranged. The ring, not round, but U-shaped and incomplete above, is placed obliquely, sometimes almost vertically. It lies midway between the anterior superior spine and the symphysis pubis, and from one-third to half-way along a line which starts at the inguinal ligament and passes to the lateral border of the rectus muscle. It has a thick and strong inner margin or pillar, a thinner outer margin, and an angle below. The opening measures in the adult from 12 to 20 mm. in height and from 6 to 10 mm. in breadth. The ring is covered anteriorly by the transversalis muscle, the fibres of the latter running obliquely

downwards and inwards. The angle of the ring lies just below the edge of the transversalis muscle to allow free passage of the cord. The ring is composed of strong U-shaped fibrous strands of varying length, the ends of which are attached firmly as slings to the posterior aspect of the

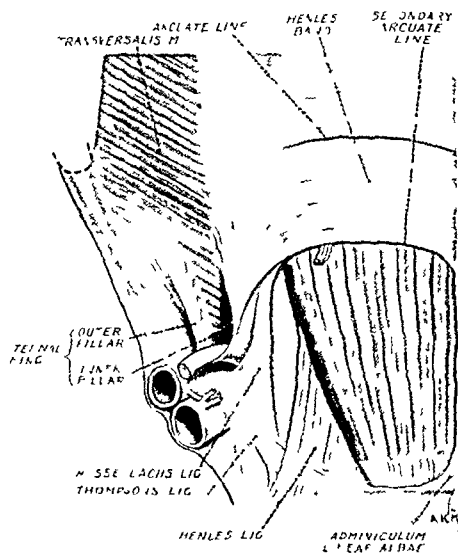


FIG. 374.—Posterior view of a dissection of the lower part of the anterior abdominal wall.

transversalis muscle. The ring has the appearance of an arum lily or horn of plenty, and the margins, which stand out, extend backwards at the angle as a tongue-shaped prolongation along the under surface of the cord. The shorter U-shaped strands form the body of the horn, while the longer strands lie on the rim. On each side of the ring the long strands spread out fanwise: on the outer side they pass up to be attached to the transversalis muscle as far as the anterior superior iliac spine; on the inner side they gain attachment to the aponeurosis of the transversalis muscle, while some pass medially to the back of the rectus muscle to join the band of Henle.

The internal ring has been thought of as an inert opening, but because of the attachment of



the ends of its slings to the back of the obliquely arranged fibres of the transversalis muscle, the ring, on contraction of the muscle, should move upwards and outwards (*Fig. 375*). This movement of the ring was first observed during a

(*Fig. 377*). The extent of ring movement can be accurately measured by attaching a thread to the ring margin at various points and exerting tension on it by varying weights carried over a pulley to which a pointer and scale are attached.

While this active movement of the ring is probably reserved as a guard against sudden and severe stress, there appears to be another protection of a more constant and passive nature provided at the opening. The margins of the ring stand out and, as the cord enters from the outer side and below, the inner margin or leaf overlaps the opening and thus acts as a lid or valve shielding it against more constant but varying changes in intra-abdominal pressure.

To fill in the outline of this conception of the ring, some further details of the anatomy of the fascia transversalis require to be mentioned. Testut (1914) describes three ligaments or bundles of reinforcement of the fascia transversalis at certain points. These are named by him the ligament of Henle, the ligament of Hesselbach, and the narrow iliopubic

band of Thompson. They are all subject to marked variation.

The ligament of Henle, situated immediately lateral to the lower end of the rectus muscle, forms a small triangle with its base downwards. It varies in height from 1 cm. to 7 cm. and the closely woven fibres which form it pass downwards and outwards. Its medial border blends with the lateral border of the rectus muscle. The lateral border facing outwards and slightly upwards is concave or falciform, hence the name *falx inguinalis* of German authors. The base is inserted into the iliopectineal line of the pubic bone, blending there with Cooper's ligament. In front the ligament of Henle is in contact with the conjoined tendon, when this is present, and the two are rather intimately blended.

The ligament of Hesselbach, or *ligamentum interfoveolare* of German anatomists, is a vertically placed band of fibres lying between the internal ring and the ligament of Henle. It is roughly triangular in shape and is fixed below by its base to Thompson's ligament. The inner margin is separated from Henle's ligament by a varying space. The outer margin blends with the fibres of the internal ring. The apex passes upwards and turns inwards across the back of the rectus muscle, where it blends with the long fibres of the internal ring to join a band of interlacing fibres known as Henle's band. The lower edge of this band is named the secondary arcuate line and lies below the semilunar fold of Douglas or arcuate line.

The narrow iliopubic band of Thompson is a ribbon of transverse fibres which extends from the iliopectineal line of the pubic bone to the anterior superior spine. The band is narrow in the centre where it passes above the femoral

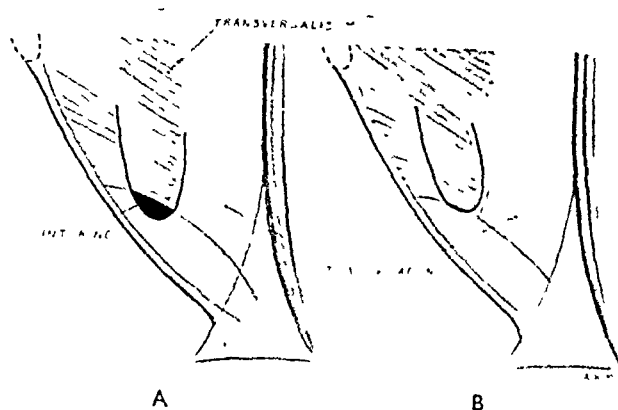


FIG. 375.—Diagrams showing the outline of the internal ring viewed from within the abdomen with the transversalis muscle relaxed (A), and in contraction (B).

hernia operation on a patient who coughed while under light ether anaesthesia. Using a local anaesthetic, ring mobility is readily demonstrated, for if the edges are held under tension and the patient asked to cough, the ring can be seen and felt to move upwards and outwards behind the internal oblique and transversalis muscles. On release of tension, movement of the ring on coughing is slight or absent. Liddell and Sherrington (1925) have shown that when a muscle is caused to contract, a stretch applied to it further enhances its contraction to a considerable degree. It would appear that the stretch reflex comes into action in protecting the inguinal canal, for it is supposed that any attempt at protrusion of the abdominal contents through the ring pulls on its slings, and by stretching the transversalis muscle calls the reflex into action. Nature thus appears to have provided a unique closure mechanism to protect the ring from the stress of increased intra-abdominal pressure, caused by such acts as coughing and straining. Its action is that of a sliding valve; it cannot well be described as a sphincter, nor yet as a shutter, for it is designed to avoid undue pressure on the cord which both these mechanisms would tend to exert. The range of movement of the inner pillar of the ring is greater than that of the outer. The inner pillar is fixed to the inner part of the transversalis muscle and to its aponeurosis where the maximum range of muscle movement occurs, while the outer pillar is attached to the muscle-fibres near their origin where the muscle only moves slightly on contraction. In addition, the attachment of the outer pillar to the muscle-fibres may be interrupted by the interposition of the upper extension of the lateral attachment of the deep femoral arch when this is well developed

vessels and broadens out into fan-shaped extremities. The inner end blends above with the ligaments of Hesselbach and Henle and not infrequently its upper fibres become continuous with the lateral border of the *adminiculum lineæ albæ*. The outer end spreads out to be inserted into the anterior superior iliac spine and the inner lip of the iliac crest.

The deep epigastric vessels are closely related to the internal ring. The artery arises from the external iliac artery below the ring and passes medially above the external iliac vein which provides its accompanying veins, one on either side. The vessels are then directed upwards and inwards behind the transversalis fascia about 1 cm. internal to the ring and pass obliquely across Hesselbach's ligament and the rectus muscle to disappear under the lower edge of Henle's band (secondary arcuate line).

### POSTERIOR WALL OF INGUINAL CANAL VIEWED FROM IN FRONT

It is perhaps not surprising that many of the anatomical details of the inguinal canal pass unnoticed by the surgeon who operates frequently for hernia. It is unnecessary to dissect the canal closely, or expose it widely, when operating for oblique hernia, while in direct hernia a deficient and distorted anatomy is usually present.

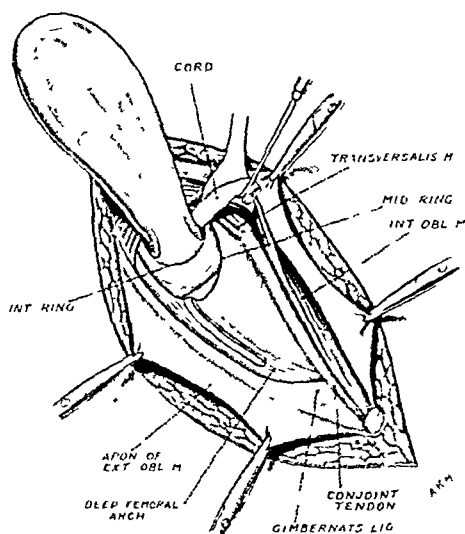


FIG. 376.—The inguinal canal exposed as at operation for oblique hernia. The sac is isolated and pulled outwards. The cremaster muscle has been removed and the cord divided.

The surgeon who ventures to explore this region in the living or dead body finds himself perplexed and enticed by a most variable and elusive anatomy. When the hernial sac is isolated from the cord and pulled forwards and outwards, the internal ring is not obvious, for it is usually closely adherent to the neck of the sac, and is also obscured by a fascial prolongation of its

margin which is continued outwards along the sac (Fig. 376). With a few touches of the knife the ring edges are easily detached from the neck of the sac and the ring becomes clearly defined.

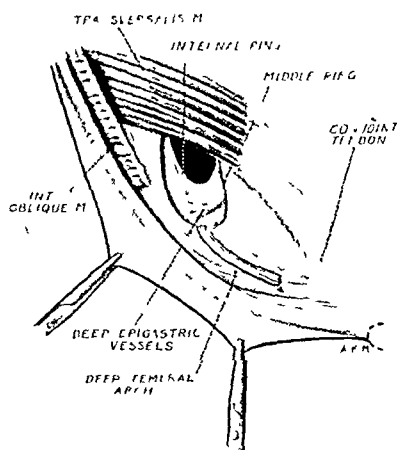


FIG. 377.—A dissection of the inguinal canal. The internal ring is shown dilated.

The U-shaped fibres of the ring embrace the neck of the sac and spermatic cord, and pass in an upward and outward direction, above and below the sac and cord, to the deep aspect of the transversalis muscle. The ring, which lies obliquely, has an inner margin which is stronger than the outer.

The deep epigastric artery runs horizontally below the ring, and turns upwards and inwards below its veins behind the posterior wall of the canal, and lies about 1 cm. internal to the ring. Occasionally the artery pierces the transversalis fascia and lies on a more superficial plane at this point.

The posterior wall of the canal internal to the ring is composed of two layers—the superficial or transversalis muscle layer supported by the deep femoral arch, and the deep layer known as the transversalis fascia.

The superficial or transversalis muscle layer (Fig. 377) is the continuation downward of the transversalis muscle and its aponeurosis. It is the stouter of the two laminae and is composed of the conjoint tendon and the transversalis muscle fascia. The conjoint tendon is often poorly developed or absent, but when well fashioned is the stronger part of this sheet, its closely woven fibres passing downwards and inwards to be attached to the inner part of the iliopectineal line. The transversalis muscle fascia continues down from the lower edge of the transversalis muscle and appears to be formed by the blending of the muscle fasciae lining its superficial and deep surfaces. Below, the transversalis muscle fascia passes behind and blends with the deep femoral arch, while laterally it often ends as a free outer margin which lies

medial to the internal ring. This edge, clearly outlined in about half the cases dissected, forms with the free margin of the deep femoral arch what I have named the middle inguinal ring. Both the conjoined tendon and transversalis muscle fascia frequently contain fine muscle-fibres.

The deep femoral arch is a strong band of pearly white transverse fibres which lies in the lower third of the posterior wall of the canal. The ligament bridges the femoral vessels and is attached medially to the iliopectineal line, while

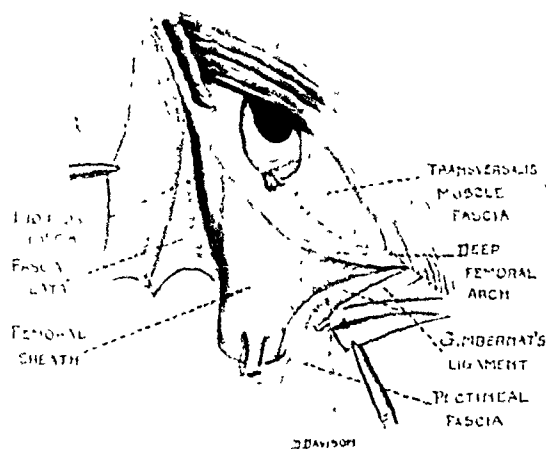


FIG. 378.—The inguino-femoral region. Poupart's ligament has been divided about 3 cm. from the pubic spine; the outer portion has been reflected laterally while the inner is being forcibly pulled forwards.

laterally it disappears under the internal oblique muscle to join the iliopsoas fascia. Its anterior surface gives attachment to the cremaster muscle. Above, the arch receives the transversalis muscle fascia; below, it blends with the posterior margin of Poupart's ligament, but the transversalis muscle fascia continues on behind the arch and Poupart's ligament and appears in the thigh as part of the anterior wall of the femoral sheath. Farther medially the lower margin of the arch is fixed to the upper surface of Gimbernat's ligament. When this connexion is severed (Fig. 378) the transversalis muscle fascia, emerging from the lower edge of the arch, is seen to turn backwards along the upper surface of Gimbernat's ligament to gain a deep attachment to the iliopectineal line. As the arch is traced outwards under the internal oblique muscle it forms the lower and outer margins of the middle ring, and terminates in the iliopsoas fascia. An expansion often passes upwards behind the transversalis muscle, insinuating itself between the transversalis fascia and the muscle. When well developed, this upward extension of the arch may disturb the attachment of the outer pillar of the ring to the transversalis muscle-fibres, and thus account for the frequent absence of mobility of the outer pillar of the ring. The middle ring, the opening

in the transversalis muscle layer through which the cord emerges, encircles the internal ring like a collar and appears to act as a support for it. Over the edge of the middle ring, at a point below and medial to the internal ring, emerge the cremasteric vessels together with the genital branch of the genitocrural nerve. These vessels, which are branches of the deep epigastric artery and veins, turn inwards, and with the nerve pass medially in their course to join the cord. When the cord is roughly displaced from its bed these vessels which anchor it may be torn and require ligature. The reflex inguinal ligament, only rarely present, lies at the inner end of the canal, but is not part of this layer.

The deep layer is the transversalis fascia, so clearly seen from behind but concealed in front by the transversalis muscle coat with which it is often fused. Thompson's ligament lies directly behind the deep femoral arch; Hesselbach's ligament, often absent, lies medial to and on the same plane as the internal ring; while the ligament of Henle is closely bound to the back of the conjoined tendon. The transversalis fascia joins with the superficial layer in forming the anterior wall of the femoral sheath.

### MUSCULATURE OF LOWER PART OF ANTERIOR ABDOMINAL WALL

The musculature of the anterior abdominal wall below the level of the anterior superior iliac spine is in striking contrast to that above this level. In the lower third of the abdomen the lateral muscles of the abdominal wall, namely the external oblique, the internal oblique, and transversalis, lie within the confines of the bony pelvis, acquire a ligamentous attachment and relinquish their connexion with the spine and iliac crest. In this region these muscles pass almost flatly across the front of the rectus muscle in contrast with the semicircular outline of the upper abdominal musculature. At the interspinous level lies the arcuate line or semilunar fold of Douglas, and below this level the aponeuroses of the internal oblique and transversalis muscles pass in front of the rectus muscle. The external oblique, strongly muscular above, is in the inguinal region entirely aponeurotic. Above, the abdominal muscles have a free and wide scope of action on the trunk, and because of the curved plane on which they act can exert a powerfully constricting force on the abdomen, and thus operate as pressure-producing muscles. Below, these muscles, confined within the bony pelvis, passing flatly across the front of the rectus muscle, and with the external oblique entirely aponeurotic, can exert little compressing force; on contraction they can, however, well resist the outward movement of the lower abdominal wall which will tend to occur when the upper abdominal muscles are in action. Walmsley (1938) points out that with their aponeuroses in front of the rectus muscle, the internal oblique and transversalis muscles act on the most curved surface which is

available and are thus at a greater mechanical advantage to effect resistance. They also contract over the rigid pillar which the contracted rectus forms for them; this pillar limiting their power to increase intra-abdominal pressure, but aiding their ability to resist it.

The lower abdominal muscles are subjected to severe and varying pressure effects by the action of the upper abdominal muscles and diaphragm, and in view of the penetration of this part of the abdominal parietes by the spermatic cord, their pressure resistance becomes highly specialized in order to protect this weak place. This protection is all the more necessary, because Nature frequently provides a freer avenue of escape for the abdominal contents by omitting to close off the processus vaginalis from the peritoneal cavity. At the entrance to the canal Nature places her first and strongest line of defence, and this is provided by the sliding valve action of the internal ring, whereby the ring is drawn upwards under cover of the transversalis muscle. In addition there is the flap-valve protection provided by the projecting inner margin of the ring. Finally, as described by Keith (1923), the canal is also protected under stress by the approximation of the lower margins of the internal oblique and transversalis muscles to the inguinal ligament.

### THE INTERNAL RING AT FAULT

The following abnormalities of the ring are found at hernia operations: (1) a dilated ring; (2) poor mobility of the ring; and (3) weakness of the ring.

1. When an oblique inguinal hernia increases in size the internal ring becomes gradually stretched. In operating on these cases, simple removal of the sac is not enough, because a dilated ring leaves a weak spot, and unless the ring is narrowed to normal size the closure mechanism does not function adequately. A dilated ring may not only be the result of, but is probably also a causal factor in hernia. There is evidence to suggest that the rare recurrence of oblique hernia in infants and the commoner recurrence in adults, after simple herniotomy, are often due to a wide ring.

2. At operations under local anæsthesia it will be noted in some cases that movement of the ring is slight or absent. This lack of mobility appears to be due to congenital defect in muscle development, to muscle or nerve damage following lower abdominal operations or injuries, or to abdominal wall weakness in older patients. Anson and McVay (1938), in a study of a large series of dissections, found that the transversalis and internal oblique muscles were frequently ill-developed in the inguinal region. Muscle weakness cannot well be remedied, but by narrowing the ring to normal size, its action, however poor, is allowed to work to the best advantage, because when the orifice is large limited movement cannot take up the slack.

3. In addition to poor ring mobility, weakness of the ring itself also occurs. The outer margin is at times found to be thin or friable. In these cases some variation of the method of simple ring suture, to be described later, is necessary.

The presence of these defects in the size, mobility, and strength of the internal ring supports Keith's (1923) view that it is not the presence of a patent process of peritoneum which accounts for hernia frequency, but a weakness in the groin in man who has had to adapt this part of his anatomy to the upright posture. He points out that in nearly all animals, man and gorilla excepted, the process of peritoneum remains open and yet inguinal hernia is rare in them at every stage of life.

### OPERATION FOR REPAIR OF THE INGUINAL RING

The hernial sac is dissected from the cord and put on the stretch by pulling it forwards and outwards. The ring is not yet clearly seen because its margin, not only adherent to the neck of the sac, is also continued outwards along

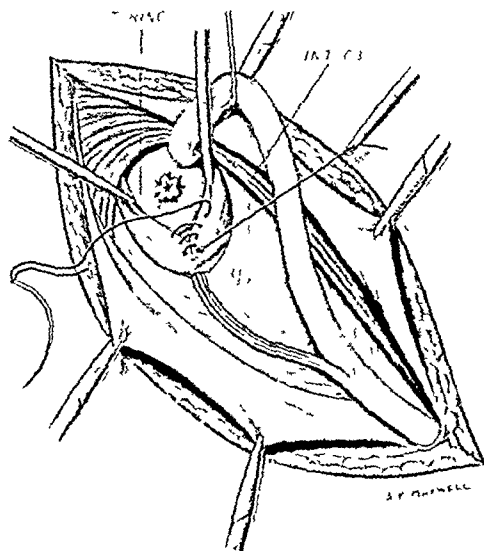


FIG. 379—Suture of the internal ring.

the sac as a thin fascial layer. When, however, the sac is opened and the finger is inserted through its neck, the firm crescentic edge of the internal ring can be distinctly felt. With the finger inside the sac, a few touches of the knife will free and define the ring margin, which is then picked up at three points by artery forceps. It is necessary at this stage to displace the cord from its bed, preferably upwards, so as to expose the ring fully and enable the sutures to be placed accurately from below upwards. The sac is ligated high up by transfixion, and allowed to fall back. The ring is now held up by the artery forceps and if the patient is being operated

on under local anæsthesia the upward and outward movement of the ring can be demonstrated if tension is exerted on the forceps and the patient asked to cough. When the ring is wide, it is sutured from below by a continuous fine silk or linen thread or chromic catgut, working upwards and outwards, until the narrowed ring covers the stump of the sac and lies snugly around the cord, against the lower margin of the transversalis muscle (*Fig. 379*). While suturing, small retractors are used to hold aside the lower margin of the internal oblique. It will be noticed that the outer margin of the ring is thinner than the inner, and in placing the sutures through the outer edge care must be taken to avoid puncture of the deep epigastric artery as it turns inwards below the ring. The operation requires some practice and nicety in placing the sutures, and it is I think advisable to have the edges of the ring under control by artery forceps, otherwise the ring tends to fall back, and is then not easily identified. On account of frequent adherence of the ring to the neck of the sac, and particularly where the sac is twisted prior to suture, the ring edges are often sutured by the surgeon who intends only to ligate the neck of the sac. Also, after simple ligature of the sac the ring edges may be drawn together by the process of healing, and in this way a natural narrowing of the ring takes place. Thus may be explained the good results often obtained in oblique inguinal herniæ with wide necks where the operation is limited to removal of the sac alone.

It is important to suture together the margins of the ring so as to reproduce its normal position and size. When the outer pillar is thin and easily torn it appears necessary to deviate from this rule, and in such cases the inner pillar should be stitched to the upper margin of the deep femoral arch rather than to Poupart's ligament which lies farther down. To displace the ring downwards alters the normal anatomy, and tends to anchor and disturb the mobility of the ring. It seems preferable, however, to repair a weak ring in this manner, than to use more difficult and doubtful methods, such as reconstruction by fascial slings.

When the internal ring is much enlarged in long-standing hernia, the layers of the posterior wall internal to it are stretched, and the inner edge of the so-called middle ring is likewise stretched. Repair of the internal ring tightens up the transversalis fascia medial to it, but leaves the middle ring enlarged and the superficial layer slack. Suture of the stretched margin of the middle ring not only restores it as a buttress for the ring, but also draws the superficial layer taut.

Occasionally the internal ring in a large or recurrent oblique hernia is so stretched and damaged that the opening in the posterior wall of the inguinal canal lies wide and immobile, the defect approaching the condition found in a direct hernia; also at times a direct and indirect hernia are associated. Here the problem of

repair is that of direct hernia, a subject beyond the scope of this paper.

Suture of the transversalis fascia is no new procedure, for it was recommended by Bassini (1890) as part of his classic operation. Suture or repair of the ring itself is more recent and has been practised by Torek (1906), Gregory Connell (1908), Bates (1913), Marsh Pitzman (1921), Major Seelig (1923), and Edmund Andrews (1924), in the United States; by Cowell (1927), Ogilvie (1929), Philip Turner (1933), Henry (1937), and Harold Edwards (1943) in this country. Some of these surgeons, however, recommend a repair which impedes the mobility of the ring.

It is important to restore, and not to interfere with, the normal anatomy and function of the inguinal canal. Bassini's operation as usually practised—that is, suture of the lower fibres of the internal oblique to Poupart's ligament without repair of the ring—must be labelled an unsatisfactory operation in oblique hernia, for it aims to reinforce the posterior wall of the canal on the inner side of the ring. Once the ring itself is forced by the commencing recurrence of a hernial sac, it is doubtful if any repair medial to the ring or on a plane superficial to it can effectively retard its progress.

### SUMMARY

The anatomy and pathology of the internal ring in action is described.

It is claimed that the internal ring has mobility and stands as an active guard at the entrance to the inguinal canal. If this is true it must follow that repair of this mechanism when at fault is an important step in restoring the canal to normal.

I am indebted to Dr. Frank Ellis, of London, for suggesting, and to his brother, Mr. Edwin Ellis, of Sheffield, for designing and making an instrument to measure ring movement; also to Miss Davison and Mr. Maxwell for their beautiful drawings.

### REFERENCES

- ANDREWS, E. (1924), *Ann. Surg.*, **80**, 225.  
 ANSON, B. J., and McVAY, C. B. (1938), *Surg. Gynec. Obstet.*, **66**, 186.  
 BASSINI, E. (1890), *Arch. klin. Chir.*, **40**, 429.  
 BATES, U. C. (1913), *J. Amer. med. Ass.*, **60**, 2032.  
 CONNELL, F. G. (1908), *Surg. Gynec. Obstet.*, **7**, 481.  
 COWELL, E. M. (1927), *Lancet*, **1**, 478.  
 EDWARDS, H. (1943), *Brit. J. Surg.*, **31**, 172.  
 HENRY, A. K. (1937), *Proc. R. Soc. Med.*, **30**, 534.  
 KEITH, SIR A. (1923), *Brit. J. Surg.*, **11**, 455.  
 LIDDELL, E. G. T., and SHERRINGTON, SIR C. S. (1925), *Proc. roy. Soc.*, **96**, 212; **97**, 267.  
 OGILVIE, W. H. (1929), *Recent Advances in Surgery*, 218.  
 PITZMAN, M. (1921), *Ann. Surg.*, **74**, 610.  
 SEELIG, M. (1923), *Arch. Surg.*, **5**, 553.  
 TESTUT and JACOB (1914), *Anatomie topographique*, **2**, 44.  
 TOREK, F. (1906), *Ann. Surg.*, **43**, 665.  
 TURNER, P. (1933), *Guy's Hosp. Rep.*, **83**, 233.  
 WALMSLEY, R. (1938), *J. Anat.*, **71**, 404.

## SOME UNUSUAL THORACIC TUMOURS

BY N. R. BARRETT AND PROFESSOR W. G. BARNARD

THIS small group of cases seemed to be worthy of publication partly because they illustrate the expanding scope of thoracic surgery which, as each year passes, brings new problems for solution, and partly because the lesions themselves may properly be described as unusual.

Two are examples of pathological lesions which occurred in the pre-pericardial pad of fat.

## PREPERICARDIAL CYST

*Case 1.*—Mr. H. M., aged 36, was admitted to St. Thomas's Hospital in March, 1943. He had noticed increasing dyspnoea on exertion over a period of six months. By profession he was a shot-blaster, and it had been assumed that the shortness of breath might have been due to his trade. He also complained of intermittent 'pressure' behind the lower



FIG. 380.—Case 1. Radiograph of chest. The cyst lies in the pericardio-phrenic angle on the right side.



FIG. 381.—Case 1. Right lateral radiograph of the chest showing the cyst lying above the diaphragm and immediately behind the sternum.

This structure has received but scant recognition from the anatomists, and its existence is not mentioned in the standard text-books. It is, nevertheless, the seat of disease upon occasion, and several interesting papers recently published in American journals have testified to this fact.

One case is that of a teratoma of the lung. We are aware of the difficulties of finally assessing the exact nature of many of the pathological processes in this organ, but, in this instance, the definite mixture of carcinomatous and sarcomatous elements leaves but little doubt of the diagnosis.

Two patients suffering from adenoma of the bronchus are included. This condition is now well recognized, but many points pertaining to the clinical features and to the wisest methods of treatment are still *sub judice*, and it is for this reason that the cases are presented.

end of the sternum, but there was nothing to suggest pain of the anginal type.

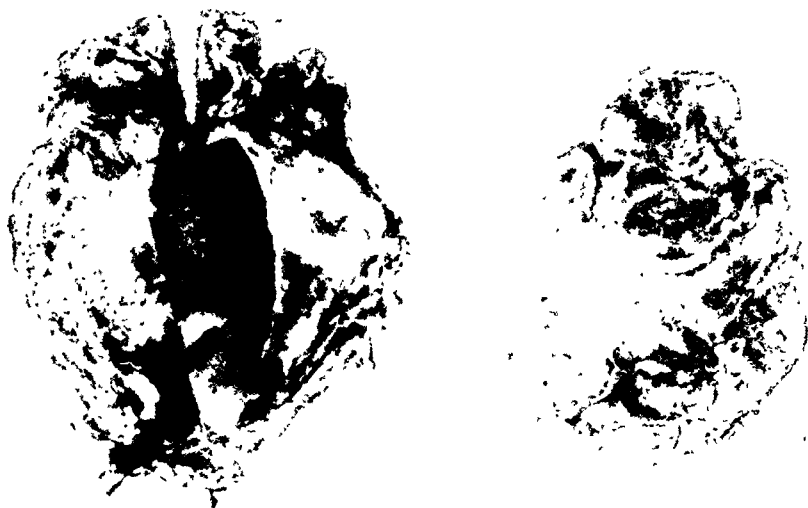
Physical examination was negative in all respects and the patient appeared to be in excellent health; but radiographs of the chest revealed an opacity, about the size of an orange, situated in the right chest and lying in the angle between the right border of the heart and the dome of the diaphragm (Figs. 380, 381). The mass lay in the extreme front of the chest, immediately behind the sternum.

The patient had an occasional cough and some mucoid sputum; the latter contained neither significant organisms nor malignant cells. The temperature, pulse, and respiratory rates were normal; the blood-pressure was 140/90 mm. of mercury and the Wassermann and Kahn reactions were negative. The bronchial tree was shown to be normal by bronchoscopy and bronchograms, and the diaphragm was not paralysed. The electrocardiograph was normal, and the possibility of a diaphragmatic hernia (through the foramen of the internal mammary

artery) was not great because a barium swallow and follow-through barium meals were normal.

Opinion was divided as to whether the mass could be held to explain the man's symptoms, and also as to whether it lay in the mediastinum, the pericardium, the lung, the pleura, or the diaphragm. Artificial pneumothorax sometimes settles a question of this type, both by showing that the lung retracts with or without the mass,

in front of the pericardium, in the pad of fat which normally is situated in this area (Figs. 382, 383). It is a thin-walled translucent cyst which contained clear watery fluid. The cyst was removed without difficulty and the chest closed. At the conclusion of the operation air was aspirated from the pleural cavity so that no pneumothorax remained. Convalescence was uneventful, and the patient was discharged from hospital a few weeks later. He has since returned to his usual work and states that he no longer suffers



Figs. 382, 383.—Case 1. Photographs of the cyst removed at operation.

and, in the case of lax cysts, such as can occur in connexion with the parietal pleura, the mass may alter in outline after air has been introduced into the pleural cavity. This method of investigation is not very satisfactory when the opacity lies adjacent to the mediastinum because the lung is attached to the central structures by the pulmonary ligament, and may not uncover a mediastinal tumour even if adhesions are not present. Artificial pneumothorax can sometimes be usefully combined with pneumoperitoneum and thoracoscopy for purposes of diagnosis.

An artificial pneumothorax was induced, but it cast no additional light upon the diagnosis or upon the point of origin of the mass. The man himself had not noticed dyspnoea as he rested in hospital, and, as he was anxious to resume work, he was discharged and kept under observation in the out-patients' department.

A month later he returned and reported that the symptoms had got worse and that he had been forced to give up his work. In particular the retrosternal "pressure" had increased. He was admitted to the Thoracic Surgical Unit at Horton War Hospital with the object of removing the "tumour". Investigations showed that the physical signs and X-ray appearances had not changed in the interval.

Thoracotomy was performed by N. R. B. on Jan. 4, 1944, under general anaesthesia administered by Dr. M. D. Nosworthy. The right pleural cavity was opened by a limited intercostal incision and the mass was immediately located lying extrapleurally,

from dyspnoea on exertion or from retrosternal pressure. Sections of the wall of the cyst showed that it was composed of fibrous tissue and lined by a single layer of flattened endothelium.

Two years ago one of us (N. R. B.) had seen a similar case in which surgical removal of an apparently innocuous mediastinal cyst, in the same position, had cured a patient of symptoms which had been diagnosed and treated as asthma. The presence of a cyst had not been suspected until radiographs had been taken. The reason why removal of such a cyst should have this curative effect is difficult to explain, but the results obtained in these two cases seem to justify surgical treatment.

Extrapleural cysts are uncommon. D'Abreu reported a small series of cases at a meeting of the Society of Thoracic Surgeons of Great Britain and Ireland in 1938. In structure his cases resembled the one we have described, but were situated towards the back of the chest wall. He did not hazard an opinion as to the pathology of the lesion.

Cysts of the mediastinum of bronchial origin have occasionally been reported (Adams and Thornton, 1943), and Hueur and Andrus (1940) have collected 25 examples of mediastinal epithelial cysts. The great majority of all the recorded cases have been situated in the upper mediastinum, or in connexion with the bifurcation

of the trachea. Churchill (1937) and Greenfield and others (1943) have reported examples which, macroscopically and microscopically, resembled the case we have described, but these were situated in the superior mediastinum and were called by them "spring water cysts". It appears that thin-walled epithelial cysts are extremely rare in the lower part of the anterior mediastinum. Lambert (1940) has described two patients, and the X-ray appearances have been recorded by Brown (1944) and others.

This whole group of cases should be carefully distinguished from dermoid cysts and teratomata of the mediastinum; which subject has been fully reviewed recently by Rusby (1944).

### ADENOMA OF THE BRONCHUS

*Case 2.*—Miss M. A., aged 8, in the summer of 1941 developed 'chest trouble', and was diagnosed and treated as a case of right-sided pleurisy and pneumonia. This illness was slow to resolve and her doctor referred the child to the Welsh National Memorial Association for X-ray examination. The films showed atelectasis of the right lower lobe and, in consequence, the patient was admitted to Llandough Hospital under the care of Dr. A. G. Watkins. He examined the child on Jan. 6, 1942, and found the physical signs of atelectasis of the right lower and middle lobes. A bronchogram made at this time revealed a block of the right main bronchus about half an inch below the carina. On April 9 Mr. Owen did a bronchoscopy and found a tumour at the level indicated in the bronchogram; it was about the size of "the tip of one's little finger". He removed the tumour by avulsing it with forceps. Its surface was smooth and covered with epithelium, and it was relatively avascular. At the conclusion of this operation it appeared that the bronchial tree was patent and that the mass had been completely removed. The child made a rapid convalescence, but the signs of atelectasis of the lower and middle lobes persisted. The pathologist's report was as follows: "The specimen shows a carcinoma-like tumour of the mucous membrane. The cells are large and arranged in solid masses and tubules. Mucinous secretion is present and in many places the tumour cells are distended with this material. The appearances suggest an origin in the mucous glands of the bronchi, and a diagnosis of carcinoma."

The patient was then transferred to Horton War Hospital and, having examined the histological specimens which Dr. Watkins sent to us, we were convinced that the tumour was an adenoma of the bronchus. Adenoma may simulate carcinoma of the bronchus histologically, and only a small fragment was available for examination.

The clinical condition of the patient was good. She was rather small and underdeveloped for her years, but the only symptoms were cough and a little purulent sputum. The signs were limited to the chest and, together with the radiographs, were typical of atelectasis and bronchiectasis of the right middle and lower lobes. The sputum was negative for tubercle bacilli and the blood-count was normal. There was no history of hæmoptysis.

On May 26 another bronchoscopy was done at Horton under avertin and local anaesthesia. The bronchial tree was normal except for a tiny patch of "roughening" on the lateral wall of the main descending bronchus immediately below the orifice of

the upper lobe bronchus. It was assumed that this patch was the healed scar which had resulted from the avulsion of the original tumour and a small piece of tissue was secured for biopsy. The bronchi of the lower and middle lobes were somewhat dilated but contained no secretions. The Sector Pathologist reported upon this tissue as consisting of a fragment of acutely inflamed respiratory epithelium and granulation tissue.

The question arose as to whether further treatment for the adenoma was desirable or necessary. Three alternative procedures were considered. Conservative treatment was discarded because it was assumed that, although bronchoscopy was negative at the time, there was certain to be an extrabronchial extension of the neoplasm and this, if ignored, would sooner or later grow into a dangerous tumour. The second suggestion was to insert radon into the bronchus, but this was also turned down because radon is now known to afford but temporary relief in the great majority of these cases, and in this particular patient the exact site of the lesion was doubtful and its placing would of necessity have been inaccurate. The third possibility was to do a lobectomy or pneumonectomy. Pneumonectomy was preferred because it was felt that the extrabronchial extension probably lay in the angle between the upper lobe bronchus and the main descending bronchus, and because the lower and middle lobes of the right lung were known to be infected and bronchiectatic.

Dissection pneumonectomy was performed (N. R. B.) on June 9 under general anaesthesia administered by Dr. M. D. Nosworthy. The child stood the operation well and left the theatre in good condition. A blood transfusion was set up and continued throughout the operation. The operation did not present any special difficulties; the pleural cavity was free except in the diaphragmatic area. The bronchus was closed with mattress sutures of fine thread, placed in its long axis, and the stump was covered with an intercostal muscle pedicle graft. At the conclusion of the operation the phrenic nerve was crushed and the pleural cavity was drained by an intercostal tube connected to an underwater seal. Convalescence was uneventful and the child made a rapid and complete recovery. The intercostal tube was removed 36 hours after the operation and sterile pleural exudate was aspirated on several occasions.

The child was sent back to Wales in August, 1942, and since that time she has continued to make excellent progress. In June, 1944, her health was very good; there was scarcely any external deformity and the pleural space on the right side had been obliterated largely by expansion of the remaining lung. When the lung, which had been removed at operation, was sectioned there was no evidence of an adenoma to be seen macroscopically in the peribronchial tissues. There were a few soft glands in the hilum and in the bifurcations of the major bronchi, and it was feared that an unnecessary operation had been done. These doubts were fortunately dispelled when serial sections of the parts had been made.

Since tumours most commonly arise at the bifurcation of bronchi the specimen was bisected through the main bronchus. Careful search failed to reveal



the stalk or base of the tumour. Histological sections were, however, made through the main bronchus to include its branches and at one junction a minute tumour was found. It was composed of solid acinar, polygonal cells (Fig. 384). Many of the cells were

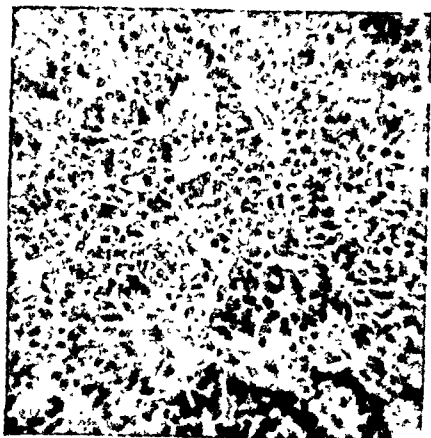


FIG. 384.—Case 2. Microphotograph of a part of the adenomatous tissue.

vacuolated. Some had a slightly spongy and others a smooth protoplasm. The cells infiltrated the mucous membrane at one spot. The remainder of the tumour was in the submucosa. It was a typical adenoma of the bronchus. The lower and middle lobes showed advanced saccular bronchiectasis.

This case is presented for two reasons. The first has already been stressed—namely, the importance of realizing that the great majority of bronchial adenomata have an extrabronchial as well as an intrabronchial part, and that this fact must be taken into consideration when treatment is planned. The second reason is that the average age of onset of symptoms in cases of adenoma of the bronchus is 28 years (Carter, 1941), and our patient was only 8 years old.

Very few adenomata have been recorded as occurring in children, and the case described is the youngest we have been able to find in which the diagnosis was certain. Beardsley (1933) reported a tumour in a child aged 10 months, but the specimen is described by him as an "adenocarcinoma", and in a recent paper Jones and others (1943) have given details of a typical adenoma occurring in a child aged 13. Wasch, Lederer, and Epstein (1940) describe a patient aged 11 who was diagnosed, upon bronchoscopy, as having an adenocarcinoma of the right upper lobe bronchus; the child died 7 years later, having developed an eosinophile adenoma of the pituitary and gigantism (quoted by Jones et al., 1943).

### ADENOMA OF BRONCHUS

Case 3.—Mrs. I. E. P., aged 32, was admitted to the Essex County Hospital in September, 1943, under the care of Dr. S. Propert. She had always been well until six weeks before admission and the first

symptoms were cough, dyspnoea on exertion, blood staining of the sputum, and pyrexia. The diagnosis at this time was judged to be pneumonia of the right upper lobe. The condition did not resolve.

Upon admission to hospital her average temperature was 100.2° F., the pulse-rate 120, and the respiratory rate 34. The physical signs (which were limited to the chest) were as follows: The right side was somewhat flattened at the apex, movements were diminished in this area and there were dullness and absent breath sounds at the right base, suggestive of a pleural effusion. The signs in the left chest indicated a mild degree of generalized bronchitis.

After a fortnight in hospital the general condition and local signs were unchanged. Radiography showed atelectasis of the right upper lobe, partial atelectasis of the right lower lobe, and possibly, a small pleural effusion. Aspirations of the right pleural cavity yielded no fluid or pus.

She was transferred to St. Thomas's Hospital, and at that time was still pyrexial, the sputum was blood-stained, and the clinical signs and radiographs were those of total atelectasis of the right lung.

Examinations of the sputum by Dr. Bamforth revealed neither tubercle bacilli nor malignant cells. There was some degree of anaemia, but no loss of weight. Within a few days bronchoscopy was performed on two occasions and on each the right main bronchus was found to be "occluded by a lobulated growth". Portions of tissue removed for biopsy did not confirm this opinion and showed only necrotic material and debris, and it was thought that the patient might have inhaled a piece of meat which had become impacted in the right main bronchus. After bronchoscopic removal of this tissue the lumen was patent.

On this account the evidence in favour of bronchial tumour was thought to be inconclusive, and conservative measures were essayed. At first the progress was satisfactory and the lower two-thirds of the lung re-expanded, but after a fortnight there was an exacerbation of all signs and symptoms associated with a high swinging temperature. A course of sulphathiazole was started and rapid resolution occurred, in fact improvement was so great that the patient was able to get up. The upper lobe was still atelectatic.

Ten days later the acute manifestations recurred and the signs again revealed collapse of the right lower lobe, and, on this occasion, a course of sulphathiazole did not produce the required effect. From now onwards the temperature was high and swinging, the sputum reappeared and was purulent and occasionally blood-stained. Her general condition began to deteriorate appreciably.

At the 8th week after admission a course of deep X rays was started in the belief that the lesion must be a carcinoma of the upper lobe bronchus, and this treatment produced no effect for good or ill in spite of the fact that there must have been considerable pulmonary suppuration at the time.

In January, 1944, the patient was transferred to the Thoracic Surgical Unit at Horton War Hospital. There was no significant change in the general or local conditions and she was still gravely ill. The right upper lobe was atelectatic, but the middle and lower lobes on that side were well aerated. Bronchoscopy (N. R. B.) was done soon after admission and this revealed a papilliferous tumour protruding into the lumen of the main bronchus, and arising from somewhere in the upper lobe bronchus. The carina was normal and there was no evidence of submucous

extending from the mediastinum to the lateral chest infiltration. The mass in the main bronchus was removed and sections of this tissue were reported upon as "oat-cell carcinoma". There was no evidence to suggest metastases in the thorax or elsewhere, and in spite of the poor general condition, thoracotomy was advised.

The operation was done by N. R. B. on Jan. 12, 1944, and a general anaesthetic was given by Dr. M. D. Nosworthy. A blood transfusion was set up and continued throughout the operation. The upper lobe was found to be densely adherent to the chest wall, and felt as though it contained a large solid mass. There was no evidence of mediastinal adenitis or metastasis, and dissection pneumonectomy was performed. The right main bronchus was closed with interrupted mattress sutures of thread, and these stitches were placed longitudinally. The bronchial stump was covered by an intercostal muscle pedicle graft. In separating the upper lobe from the chest wall the pulmonary parenchyma was opened in one place and some pus escaped from the lobe into the operation field. The chest was closed without drainage.

Immediately after the operation the patient developed a fulminating bronchitis of the left lung which was interpreted as a flare-up of the condition already known to be present. After five days her condition improved rapidly and subsequently convalescence was uneventful. The chest was aspirated on one occasion only, and a few ounces of sterile fluid were obtained.

The patient left the hospital in March, 1944, and her health has improved steadily since that time.

Macroscopic section of the lung which had been removed showed a pedunculated tumour, arising in the right upper lobe, from the point of division of the upper lobe bronchus into its three bronchopulmonary segments (Fig. 385). The stalk of the tumour filled

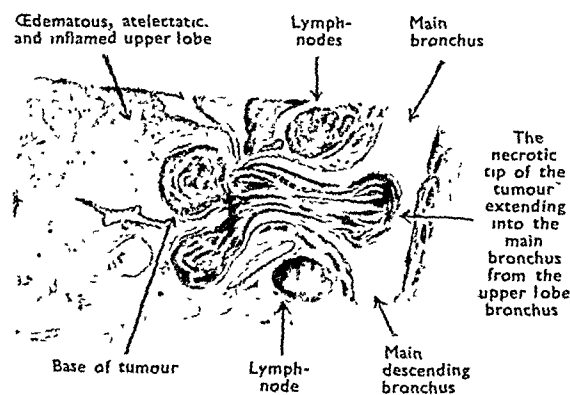


FIG. 385.—Case 3. Diagram to show the macroscopical appearance of a large section cut across the upper lobe of the right lung.

the upper lobe bronchus and its bulbous end lay in the right main bronchus. Peripheral to the tumour, the base of which measured about 1 cm. across, the upper lobe was in a state of acute pulmonary supuration. In the right lower lobe bronchus there was a large piece of the tip of the tumour which had broken off and become impacted, and this had caused inflammation of the obstructed lower lobe.

The histology of the tumour was as follows: Solid acinar and tubular, polygonal, cubical, and

columnar-celled adenoma of bronchus. The walls of the affected bronchi were infiltrated at their bases. No infiltration of bronchial lymph-glands was seen.

This case is presented because of certain features which are of special interest:—

1. The explanation of the recurring conditions of atelectasis and re-expansion of the lower and middle lobes was that it was partly due to the blocking of the main bronchus by the growing tip of the tumour and partly to the fact that portions of the tumour became necrotic, broke off, and impacted in the lower lobe bronchus. Thus it is obvious why, at one time the whole lung was atelectatic, at another only the upper and lower lobes, and sometimes only the upper lobe.

2. This tumour was not established as an adenoma until the whole lung was available for microscopy. The fact that an oat-cell carcinoma had been diagnosed from the material secured at bronchoscopy, might have been disastrous to the patient, for it has been stated by some experienced thoracic surgeons that oat-cell tumours of the main bronchus metastasize so early to the mediastinal glands that thoracotomy is scarcely worth while. In this case the appearance of the tumour at bronchoscopy and the normality of the carina were so suggestive of adenoma that a blind eye was turned to the pathologist's report and pneumonectomy was performed.

3. This tumour grew from a relatively small base into a pedunculated projection which occupied the whole of the upper lobe bronchus; this particular arrangement is peculiar in that the pedicle was much longer than is usual.

4. In spite of the fact that the pleural cavity was contaminated by pus during the mobilization of the upper lobe, and the chest was closed without drainage at the end of the operation, the patient did not develop an empyema. In consequence of this, convalescence was a matter of weeks as opposed to months. All recent experience goes to show that the pleural cavity can effectively control a fair degree of contamination in the course of an operation, but that any surgical procedure which allows repeated or continuous infection (such as the development of a bronchial fistula) is certain to be followed by an empyema. In this respect the behaviour of the pleural cavity is like that of the peritoneum.

## INTRATHORACIC LIPOMA

Case 4.—Master C. B., a little boy aged 4, was admitted to the Thoracic Surgical Unit at Horton War Hospital in October, 1943. His mother stated that he had had asthma, measles, and chicken-pox; a year before his admission he had been taken into another hospital on account of catarrhal jaundice. Whilst he was convalescent from this condition he is said to have developed a "left pleural effusion", but needling at the time did not yield any fluid. Physical signs were limited to the left side of the thorax, and his general condition was excellent. The signs indicated a solid, or fluid, space-occupying lesion situated in the front of the left chest and

wall, and from the level of the 3rd rib above to the dome of the diaphragm below. X rays confirmed these signs and also showed that the heart was considerably displaced into the right chest. There was no alteration in sensation of the overlying skin, no finger clubbing, no cough or sputum. The temperature, pulse, and respiratory rates were normal, as was the general development of the child.



FIG. 386.—Case 4. Postero-anterior film of the chest showing the opacity in the left hemithorax and displacement of the heart to the right.

In March, 1943 (i.e., 7 months before admission to Horton War Hospital), the chest was needled again as the physical signs persisted and a "tiny" piece of structureless material resembling "fibrin" was obtained. Apparently the possibility of hydatid disease was entertained, but the blood-count and Casoni test were negative. A bronchoscopy was carried out under general anaesthesia; the bronchi of the left lower lobe were displaced upwards and outwards, but no intrabronchial abnormality was detected. A barium swallow proved that the mass lay well forward of the oesophagus and X rays showed that it was evenly dense throughout, and that the edges were slightly irregular, as though it was lobulated in places. Bronchograms did not afford additional information except that they confirmed the opinion that the lesion was extrapulmonary.

When the boy was admitted to Horton he was stated to be suffering from "an interlobar effusion (presumably between the upper and lower lobes of the left lung) containing a mass of fibrin". Clinical and X-ray examinations did not reveal any additional abnormalities except that there was a definite bulging of the chest wall in the area occupied by the mass (Figs. 386, 387). It was also apparent, from a study of the serial radiographs, that there had been no appreciable change in the shadow over a period of one year during which its presence had been appreciated.

Reviewing the available evidence it seemed that a diagnosis of interlobar effusion was not

likely to be correct. It had been made upon the fact that a minute mass of "fibrin" had been aspirated upon one occasion, and upon the lateral radiographs and bronchograms. The latter showed that the opacity lay between what, at first sight, was thought to be the upper and the lower lobes of the left lung. This



FIG. 387.—Case 4. Left lateral radiograph of the chest showing a very large opacity extending from the vertebral column to the back of the sternum.

interpretation was fallacious, because these appearances had been produced by reason of the fact that a good quantity of the lipiodol had run



FIG. 388.—Case 4. Photograph of the lipoma removed from the left hemithorax.

over into the lower lobe of the right lung, so that when the lateral films were examined the bronchial trees on the two sides were superimposed.

The most likely diagnosis was considered to be a mediastinal tumour, and, of the various possibilities, the lobulated outline suggested a teratoma or a benign tumour such as a lipoma.

Whilst the patient was in hospital, tonsillitis occurred, and when the acute phase had subsided, the tonsils were removed without event.

Thoracotomy was done by N. R. B. on Dec. 28 and a general anaesthetic was given by Dr. M. D. Nosworthy. A blood transfusion was set up as a preliminary to operation. The left chest was opened by removing the 7th rib. The tumour lay in front of the heart, and extended along the diaphragm to the lateral chest wall. It was bigger than the X rays had suggested and was about the size of a large grape-fruit. It was yellow in colour, loculated, solid, and with a number of small secondary excrescences upon its surface (Fig. 388). A slender capsule enclosed the mass, and the excrescences seemed to have herniated through this capsule. There were delicate adhesions between the tumour, the chest wall, the diaphragm, and the pericardium; its pedicle arose from the prepericardial pad of fat. Removal of the tumour was not difficult and was accomplished in about fifteen minutes, but, from the moment the pleural cavity had been opened, the condition gave rise to anxiety, and during the course of the operation it seemed as though the child might die. The operation had not been done without a fair amount of bleeding and a pint of blood was run into the saphenous vein fairly quickly at the critical moment. The chest was closed without drainage and, when the air in the pleural cavity had been aspirated, the general condition improved rapidly so that, by the time the patient had reached the ward, there was no further cause for anxiety. The anaesthetic record is shown in Figs. 389 and 390.

Convalescence was uneventful. A small effusion of blood-stained serum collected in the pleural cavity; this was aspirated and the child got up on the tenth day. Six months after operation he attended the follow-up department and there were no abnormal signs or symptoms.

Histologically the tumour was a lipoma. There was no evidence of malignancy.

The first case of thoracic lipoma was recorded by Fothergill in 1783.

In 1940 McCorkle and others reviewed the literature and found only 34 recorded examples; Hueur (1933) has also reviewed the subject and he divides the cases into three groups, namely:—

1. The intrathoracic tumour has an extension outside the ribs, so that the tumour has an hour-glass shape.

2. The tumour extends into the neck.

3. The tumour is purely intrathoracic.

Many of these tumours are symptomless for a long time, and are eventually discovered either in the course of routine examination of the chest or on account of pressure symptoms. There is no certain method of diagnosis and Alexander (1942) has stated that "the most circumscribed

PATIENT DATA		ANESTHETIC RECORD		POSTOPERATIVE COMPLICATIONS	
SEX (A)	AGE (B)	NO.	WARD	RESP. MAJOR	RESP. MINOR
F	5	100/60	B3	CVS	CVS
10	5	NAME	CHARLES BARTON	CNS	CNS
20	5	B.P.	100/60	GU	GU
40	5	T.P.R.	97	GASTRO	GASTRO
60	5	Wt	20	INTESTINAL	INTESTINAL
61	5	WBC	10,000	METABOLIC	METABOLIC
51		DATE	28 DEC 43	TECHNIQUES (F)	
1		DIAGNOSIS & OPERATION PROPOSED	THORACOTOMY	1. EMERGENCY	
2		DETAILS OF PREOPERATIVE COMPLICATIONS AND PREVIOUS ANESTHETIC HISTORY	for mass filling most of Lt. chest	2. IV THERAPY	
3		DETAILS OF POSTOPERATIVE COMPLICATIONS	Plump - apparently fit child.	3. CVS	
4			Deformity of ribs of Lt. chest	4. RESPIRATORY	
5			Wale on tumour. Mass	5. ADMINISTRATION	
6			increasing in size	6. REFLEXES	
7			Soon picked up - a.c. ed	7. MAX DEPTH	
8			lastly in 20 minutes time.	8. MAINTENANCE	
9			vomited repeatedly brought up	9. OTHER	
10			Good stained sputum.	10. OTHER	
11			vomiting continued 3 days	11. OTHER	
12			1 v saline given otherwise OK.	12. OTHER	
13			Thereafter straight forward	13. OTHER	
14			curative cure	14. OTHER	
15		RESULT	✓ Lab. Report on tumour	15. OTHER	
16			Lipoma	16. OTHER	
17		CAUSE OF DEATH (U)		17. OTHER	
18		(T) TIME OF DEATH (S)		18. OTHER	
19		(R) REASON FOR DEATH		19. OTHER	
20		(I) ILLNESS		20. OTHER	
21		(P) PAIN		21. OTHER	
22		(Q) QUANTITY		22. OTHER	
23		(R) RATE		23. OTHER	
24		(S) SITE		24. OTHER	
25		(T) TYPE		25. OTHER	
26		(U) USE		26. OTHER	
27		(V) VALUE		27. OTHER	
28		(W) WEIGHT		28. OTHER	
29		(X) X-RAY		29. OTHER	
30		(Y) YIELD		30. OTHER	
31		(Z) ZONE		31. OTHER	

FIG. 389.—Front of anaesthetic record card of Case 4. The positive factors have been punched out.

intrathoracic neoplasms are not extrapulmonary and benign, but intrapulmonary and malignant", so that the only way of finding out is to do a thoracotomy. Exploratory thoracotomy is now almost as safe as laparotomy (Overholt and Souders, 1937), but to remove a large tumour from the pleural cavity is dangerous. Clagett and Hausmann (1944) make the following observations about this point: "The margin of respiratory

she felt run down, but was eventually able to get back to her work. She began to be troubled by a cough, which was productive and kept her awake at night-time, and by a feeling of heaviness in the front of the right chest. By April these symptoms had been aggravated by dyspnoea upon exertion and by a feeling of generalized and increasing weakness. Since the onset of her illness she had been bringing

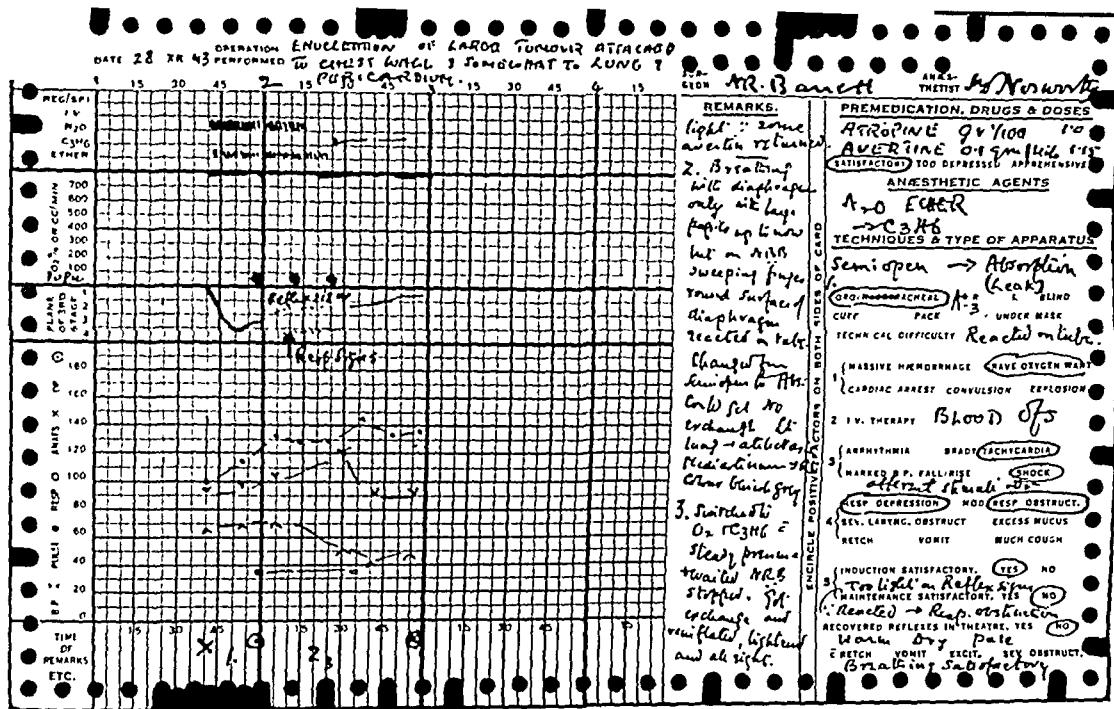


FIG. 390.—Back of anæsthetic record. In this case the deterioration in the patient's condition was due, in Dr. Nosworthy's opinion, to the fact that the level of anæsthesia was too light.

The largest intrathoracic tumours which have been described have been lipomata, although dermoid cysts and fibromata (Clagett and Hausmann, 1944) can match them in this respect.

*Case 5.*—Miss W., aged 40, was admitted to the wards of the Thoracic Surgical Unit at Horton War Hospital on Aug. 12, 1943.

up sputum; at first this was frankly purulent and amounted to  $\frac{1}{2}$  pint a day, but as the summer came she began to feel a little better and the sputum diminished to an ounce in the 24 hours.

The patient then came to London and was admitted to St. Thomas's Hospital under the care of Dr. Gardiner-Hill. Her general condition at that time was poor, for, although the temperature was normal, she had lost a great deal of weight and was suffering from the effects of a marked secondary anaemia. Her cough and sputum were still present and the physical signs were dullness to percussion and absent breath-sounds over the middle thirds of the front and back of the chest. Anteroposterior and lateral radiographs were taken and showed an opacity similar to that which has already been described (*Figs. 391, 392*). The radiological diagnosis suggested by these films was pulmonary hydatid cyst, and a Casoni reaction, which was negative, was done. The alternative diagnosis was a peripheral tumour of the lung.

It has been said that the radiographic appearances of a simple hydatid cyst in the lung are diagnostic of the condition; this is not true (Barrett and Thomas, 1944). The circumscribed opacity, seen in the anteroposterior film of this patient, is quite consistent with hydatid disease, and the presence of a negative Casoni reaction

unable to find any malignant cells. It was at this stage that the patient volunteered the information that, whilst in the West Country, she had on one occasion, coughed up a dark-red object about the size of her forefinger. Her doctor had recognized this object as a bronchial cast and had sent it to Exeter for examination. The report was blood-clot containing masses of malignant cells. Later on, Dr.



FIG. 391.—Case 5. Postero-anterior radiograph of the chest showing the tumour in the right lung. It was upon this film that the diagnosis of hydatid disease had been made, and the X-ray appearances (as seen in this film) are compatible with this condition.

does not rule it out, especially in a case of uncomplicated pulmonary cyst. The lateral film of this patient is, however, not consistent with such a diagnosis, for, in the front of the opacity, there is an area of diminished density which is irregular in shape. If this lesion were in fact an hydatid cyst it must be one in which air has got into the space between the adventitia and the laminated membrane or actually into the cyst itself. In the first event the appearances produced are those of a crescent of air, of *regular* outline, circumscribing the intact hydatid membranes (i.e., a 'perivesicular pneumocyst'), or in the latter case the picture is of a cavity in the lung probably containing a fluid level. Now in this particular patient there was no clinical evidence that a cyst had ruptured and the lateral X-ray film was not typical of either of the conditions described above (Fig. 393), and for these reasons the diagnosis of pulmonary tumour was preferred to that of hydatid disease. Subsequent events proved that this reasoning was correct and that the area of diminished density under discussion was, in fact, due to an area of necrosis in the tumour.

The health of the patient was deteriorating rapidly and the sputum was now blood-stained. Dr. Bamforth examined several specimens of sputum, but was



FIG. 392.—Case 5. Right lateral radiograph of the chest. In this view the opacity is not only lobular but there is an area of diminished density in the front. If this were a hydatid cyst it would be one in which air had become insinuated between the adventitia and the laminated membrane and in this case the area between the arrows and the main bulk of the mass should be a perfect crescent like a new moon. It was upon this film that the diagnosis of tumour in the lung was made.

Bamforth was able to examine this slide himself and to confirm the above diagnosis. The patient was then seen by one of us and transferred to Horton War Hospital for surgical treatment.

On admission her condition was very poor, and, in addition to the state already described, she was irrational and most difficult to handle. A bronchoscopy was done (N. R. B.) on Aug. 17, 1943, under local anaesthesia and nothing abnormal was detected in the bronchial tree. There was no evidence of metastases.

The fact that masses of groups of malignant cells had been found in the bronchial cast which the patient had expectorated and that, in spite of this, the main bronchial tree was normal is of considerable interest, for it has been alleged (Overholt) that malignant cells are only likely to be found in the sputum when the tumour is papilliferous and situated in close proximity to the carina. The present case confirms the opinion of Dudgeon (1935), who devised the most satisfactory technique for demonstrating malignant cells in the sputum, and others (Barrett, 1938; Gowar, 1943) that peripheral tumours as well as tumours situated in the main bronchial tree can shed malignant cells into the sputum.

On Aug. 24, a dissection pneumonectomy was performed (N. R. B.) under general anaesthesia given by Dr. M. D. Nosworthy. A blood transfusion was set up as a preliminary to operation. The lung was

days later, when the exhibition of sulphathiazole was stopped and the temperature and pulse immediately fell to normal. From this time onwards convalescence was straightforward and the patient was able to get up at the end of the third week. Her general health, and especially her mental state, were better at this time than they had been for many months; she stated that she 'almost felt a normal individual again'. The pleural cavity was not aspirated after the second week because the effusion became absorbed spontaneously.

It is easy to account for the complications described above when all the facts are told, but the cause was not appreciated at the time. The patient had been given an overdose of sulphathiazole. It is arguable that prophylactic sulphonamides should never have been given in this case as there was no reason to anticipate pleural suppuration, but, however this may be, there is no doubt that when these drugs are given the total dose (as well as the daily dose) should be recorded on the patient's chart every day. This particular patient received 68 g., and it is interesting to note that rigors were a part of the clinical picture and that the volume of urine excreted was never low.

The patient was discharged from the hospital on Oct. 12, and when seen one year later was in very good health. The pleural cavity was quite dry and the pneumothorax, on the operated side, had already diminished greatly in size. She had returned to her



FIG. 393.—Radiograph of a patient suffering from pulmonary hydatid disease. There are three hydatid cysts in the lungs: (1) In the right lower zone is an uncomplicated simple cyst; (2) In the right upper zone a cyst with a perivesicular pneumocyst; (3) In the left middle zone a cyst which has ruptured into a bronchus. These 'circular opacities' should be compared with that which occurred in Case 5.

removed without difficulty and the bronchus occluded with interrupted stitches of thread; the bronchial stump was covered with an intercostal muscle pedicle graft. At the conclusion of the operation the phrenic nerve was crushed and the pleural cavity closed without drainage. The pleura was free of adhesions and there were no metastases to be seen or felt in the mediastinum. After the patient had been turned on her back the intrapleural pressures were adjusted to a mean atmospheric, on the side of the operation, and the general condition was good.

Next day a course of sulphathiazole was started, as a prophylactic measure against pleural infection, and the patient's temperature and pulse-rate were slightly raised. She then began to run a niggling temperature which was controlled by repeated aspirations of small quantities of bloody serum from the pleural cavity; but on the whole her condition never gave rise to any anxiety until the eleventh post-operative day. At this time she developed a high swinging temperature, with occasional rigors; the pulse-rate rose to between 110 and 120 and the outlook suddenly became very bad. It was at first assumed that infection had occurred in the pleura, but all specimens obtained by aspirations were sterile upon culture and specimens of the urine were also sterile upon culture. The output of urine was normal. The condition of the patient, which now resembled a state of septicaemia, rapidly deteriorated until three

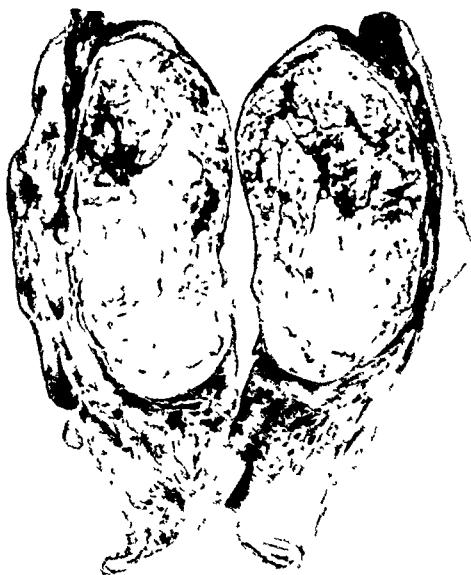


FIG. 394.—Case 5. Photograph of the right lung, cut open to show the appearances of the tumour.

work as a secretary. The pathological report upon the tumour (Fig. 394) was as follows: "The tumour is a mixed carcinoma and sarcoma of lung. The two types of tissue are closely mixed. The epithelial part in places produced tubes, or parts of tubes, lined

by multi-layered columnar epithelium resembling an immature bronchus. In places there are papillae covered by similar epithelium and having a delicate fibrous tissue core. There are a few scattered groups of small polygonal cells very like those seen in one form of adenoma of bronchus. The connective tissue part varies from sheets of closely packed round or oval nuclei with practically no cell outline or protoplasm, to spindle cells running in bands; some more mature cells are also present and these are producing fibre and gland cells.

"In many places the epithelial-lined tubes are surrounded or partly surrounded by connective-tissue cells very much like the arrangement in some embryomata of kidney. This arrangement and grouping also resembles the bronchial buds growing into the undifferentiated mesoderm in the developing lung of an embryo.

"It is possible that the tumour has developed from a part of lung which has remained dormant and undeveloped, or that the tumour is recapitulating its own life history."

This case has been recorded because the pathological findings are most unusual.

#### REFERENCES

##### Prepericardial Cyst.—

- ADAMS, W. E., and THORNTON, T. F. (1943), *J. thorac. Surg.*, **12**, 503.  
BROWN, R. K., and ROBBINS, L. L. (1944), *Ibid.*, **13**, 84.

- CHURCHILL, E. (1937), *New. Engl. J. Med.*, **217**, 958.  
GREENFIELD, I., STEINBERG, I., and TOUROFF, A. S. W. (1943), *J. thorac. Surg.*, **12**, 495.  
HUEUR, G. J., and ANDRUS, W. DE W. (1940), *Amer. J. Surg.*, **50**, 143.  
LAMBERT, A. V. S. (1940), *J. thorac. Surg.*, **10**, 1.  
RUSBY, N. LL. (1944), *Ibid.*, **13**, 169.

##### Adenoma of Bronchus.—

- BEARDSLEY, J. M. (1933), *Canad. med. Ass. J.*, **29**, 257.  
CARTER, A. P. FOSTER (1941), *Quart. J. Med.*, **10**, 139.  
JONES, R., MACKENZIE, K. W., and BIDDLE, E. (1943), *Brit. J. Tuberc.*, **37**, 113.  
WASCH, M. G., LEDERER, M., and EPSTEIN, B. S. (1940), *J. Pediat.*, **17**, 521.

##### Intrathoracic Lipoma.—

- ALEXANDER, J. (1942), *J. Amer. med. Ass.*, **119**, 395.  
ANDRUS, W. DE W. (1935), *J. thorac. Surg.*, **4**, 236.  
CLAGETT, O. T., and HAUSMANN, P. F. (1944), *Ibid.*, **13**, 6.  
HUEUR, G. J. (1933), *Ann. Surg.*, **98**, 801.  
McCORKLE, R. G., KOERTH, C. J., and DONALDSON, J. M. (1940), *J. thorac. Surg.*, **9**, 568.  
OVERHOLT, R. H., and SOUDERS, C. R. (1937), *S. Clin. N. Amer.*, **17**, 905.

##### Mixed Carcinoma and Sarcoma of Lung.—

- BARRETT, N. R. (1938), *J. thorac. Surg.*, **8**, 169.  
— and THOMAS, D. (1944), *Brit. J. Tuberc.*, **38**, 39.  
DUDGEON, L. S. (1936), *St. Thomas's Hosp. Rep.*, 2nd ser., **1**, 51.  
— and WRIGLEY, C. H. (1935), *J. Laryngol.*, **50**, 10.  
GOWAR, F. J. SAMBROOK (1943), *Brit. J. Surg.*, **30**, 193.

## THE COMPLICATIONS OF ACQUIRED DIVERTICULOSIS OF THE JEJUNUM AND ILEUM

By R. MILNES WALKER

ROYAL HOSPITAL, WOLVERHAMPTON

ACQUIRED diverticulosis of the jejunum and ileum, which, until recently, was considered a pathological curiosity, has been shown, when careful observations have been made, to be not an exceedingly uncommon condition, and many surgeons and post-mortem pathologists will have come across examples during routine examinations of the small intestine. Up to the present time approximately 225 examples have been recorded in the literature, but this must represent only a very small fraction of their incidence; Rosedale and Lawrence (1936) found the condition 4 times in 300 autopsies when they undertook routine insufflation on the small intestine in situ in order to demonstrate the diverticula, while Rankin and Martin (1934) state that diverticulosis of the jejunum or ileum was found at the Mayo Clinic 3 times out of 956 radiographic examinations in which the small bowel was specially studied.

**Historical Note.**—This note is inserted to correct an error which has crept into the literature, and has been reproduced in the majority of papers on this subject during the last twenty-five years—namely, that the first example was described by Astley Cooper

in 1844; this is manifestly an error, for this surgeon died in 1841, and reference to the first edition of his *Anatomy and Surgical Treatment of Crural and Umbilical Hernia* (p. 87), published in 1807, yields an account of his case, a man of about 50 years of age who died in the London Hospital of "general dropsy", and had a "diseased state of the liver". Astley Cooper's original engraving gives such an accurate delineation of a typical example of diverticulosis of the jejunum that I make no apology for reproducing it nearly a century and a half after its original appearance (Fig. 395).

The pathology and aetiology of this condition have in recent years been investigated and fully discussed by Edwards (1939), Fraser (1933), and Butler (1933) in this country, and the literature reviewed by Gerster (1938) in America. The condition is an acquired one, and the diverticula are of the mucous membrane hernia type, and as a rule find their way through the muscular coat of the intestine at the points where the main arteries pierce the muscle; they therefore occur almost exclusively on the mesenteric border, just to one or other side of the midline of the mesentery. The upper jejunum is the



portion of small intestine which is most commonly affected, but cases are on record in which the whole of the jejunum and part of the ileum were involved; examples are rare in which acquired diverticula are found in the ileum alone, and in such cases they are usually solitary; when the

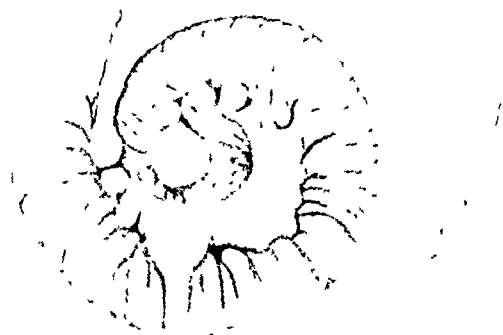


FIG. 395.—The first drawing of a specimen from a case of diverticulosis of the jejunum, reproduced from Astley Cooper's *Anatomy and Surgical Treatment of Crural and Umbilical Hernia*, 1807.

upper jejunum is involved, the diverticula are almost always multiple, and the number may run into hundreds. In the jejunum they grow to a large size, up to 3 in. in diameter; they have thin walls, and wide orifices by which they communicate with the lumen of the intestine; when they are found in the ileum, and particularly in its lower portion, they approximate more closely in appearance to the false diverticula which are so common in the colon, being small in size, and having a narrow communication with the intestinal lumen. Like diverticulosis of the large intestine this is a disease of later adult life, and not many examples have been recorded under the age of 40; it also resembles the condition when found in the colon, in that the majority of cases give rise to no symptoms, and are only found incidentally at autopsy, or on radiological examination of the alimentary tract for some other condition; it must be borne in mind, however, that very often no abnormal radiological appearances are produced, even when special methods are adopted to demonstrate the upper jejunum, so that a negative examination is of no value in excluding the condition. Some patients suffer from a flatulent type of dyspepsia,

which has been carefully described by Edwards, and which may be so severe as to call for surgical treatment. This dyspepsia, though occurring in the minority of persons who have jejunal diverticulosis, must be considered a symptom of the primary condition and not the result of complications, as at operation on such patients no evidence of any secondary changes can be found. I have met with a single example of such an uncomplicated case without symptoms, in a man of 57 who was undergoing an operation for pyloric stenosis; in the upper loop of jejunum were five diverticula, all on the mesenteric border, and within a few centimetres of each other; four were small, not more than 1 cm. in diameter but the fifth had a diameter of 2 cm.

The complications to which jejunal and ileal diverticula may give rise are:—

1. Acute diverticulitis, causing:—
  - a. General peritonitis.
  - b. Localized abscess.
  - c. Adhesions.
  - d. Acute intestinal obstruction.

These complications may or may not be associated with an actual perforation.

2. Concretion formation, which may cause intestinal obstruction.
3. Hæmorrhage.
4. Traumatic rupture.
5. Volvulus.

### 1. ACUTE DIVERTICULITIS

This is the most frequent complication, but the rarity of complications in general is emphasized by the fact that acute diverticulitis of the small intestine, after exclusion of congenital diverticula, has only been recorded 19 times, though 3 further examples are given below.

### CASE REPORTS

*Case 1.*—M. W., a married woman of 32, was admitted to the Royal Hospital, Wolverhampton, on Oct. 10, 1931, with a history of vomiting and colicky upper abdominal pain of 24 hours' duration; no fæces or flatus had been passed after the onset of the pain, and there was no history of any previous abdominal symptoms. Her temperature was  $101.4^{\circ}$ , pulse-rate 132, and respirations 26, and the tongue was dry; she was tender and rigid in the left upper quadrant of the abdomen, but no tumour was palpable; a diagnosis of small-intestine obstruction was made, and laparotomy carried out.

*AT OPERATION.*—No free fluid was present; most of the small intestine was collapsed and empty, but the upper loop of jejunum was distended, and about 30 cm. from the duodenojejunal flexure was an inflamed intramesenteric diverticulum 2 cm. in diameter, causing considerable œdema of the adjacent mesentery, and so much œdema of the wall of the jejunum that the latter was completely obstructed at this point; as no other diverticula were observed, the inflamed area was excised, including 12 cm. of jejunum, and end-to-end anastomosis carried out.

*PROGRESS.*—The patient made an uneventful recovery. She was seen again in December, 1941, ten years after her operation; she had had no further abdominal symptoms, and was in excellent

health; radiological examination then showed no evidence of diverticula in the small intestine, though she was examined expressly with this in view.

**THE SPECIMEN.**—The diverticulum had a wide communication with the intestine; it was mainly occupied by gas, but contained a little pus; the mucous membrane was so necrotic as to be unrecognizable to the naked eye, but there was no perforation



FIG. 396.—Case 1. Low-power view of a section through the wall of the diverticulum. Note the absence of a muscular coat, the necrosis of the mucous membrane, a trace of muscularis mucosae, and intense infiltration of the submucosa and of the mesenteric fat by polymorphonuclear leucocytes.

either into the mesentery or the peritoneum. Microscopical examination showed a lining of necrotic jejunal mucous membrane, no evidence of the presence of a muscular coat, but intense polymorphonuclear inflammatory reaction in the adjacent mesentery (Fig. 396).

**Case 2.**—L. R., a married woman of 62, was sent into the Royal Hospital, Wolverhampton, on Nov. 1, 1943. She stated that she had been in good health until two days before, when she developed a pain across the upper abdomen, going through to the back, and later settling on the right side; she had vomited at the time of the onset of the attack, but not subsequently, and her bowels had moved the day before admission. In view of the findings it is noteworthy that she confessed to no previous abdominal symptoms. She was an exceedingly stout woman, with a temperature of 98.8° and pulse-rate of 110. Cardiac examination was negative. She was tender in the right upper and lower and the left lower quadrants of the abdomen, the maximum tenderness being to the right of the umbilicus.

**AT OPERATION.**—Laparotomy, which was carried out through a right paramedian incision, revealed no free fluid. The appendix was thickened and adherent to the adjacent caecum; the gall-bladder felt normal; at this time a mass was felt among the loops of upper jejunum, and on separating these an abscess was opened containing about 5 oz. of thick odourless pus; diverticula were then observed along the mesenteric border of the gut, so after the pus was evacuated the jejunum was examined more closely; 7 cm. below the duodenojejunal flexure, the jejunum first formed the wall of the abscess, and it was

oedematous from here downwards; the highest diverticulum was 15 cm. from the flexure, below which they were numerous on both sides of the mesenteric border for a distance of 45 cm., but there was no inflammatory swelling in relation to the lower diverticula. At a point 30 cm. from the flexure was the largest diverticulum, 5.0 cm. in diameter, and immediately below this was a solid mass extending into the mesentery, which showed the most pronounced inflammation in this area. At the time it was thought that the condition was complicated by a malignant growth, but subsequent examination of the specimen showed this to be incorrect. The affected length of jejunum was excised, with end-to-end anastomosis, and after the abscess cavity had been sprayed with sulphanilamide powder the wound was closed, with provision for drainage.

At first the patient made good progress, but she died suddenly on the third day after operation. Autopsy showed the site of anastomosis to be covered with fibrin, but no peritonitis, and no re-accumulation of pus at the site of the abscess; examination of her heart, however, revealed coronary thrombosis and myocarditis, which was established as the cause of death.

**THE SPECIMEN (Figs. 397, 398).**—The specimen consists of 75 cm. of jejunum; throughout most of its length are diverticula on either side of the mesenteric border, but the mesenteric fat masks the smaller ones which are only demonstrable from inside the lumen; just above the centre of the specimen there is a firm swelling in the mesentery, extending from the wall of the jejunum in the region of one of the larger diverticula, while most of the surrounding mesentery and the whole thickness of the intestinal wall in this area are oedematous. On examination of the lumen, there are 41 diverticula varying in size from a pea to 5 cm. in diameter, and their paired arrangement on each side of the mesenteric attachment is clearly seen. They all have wide mouths,

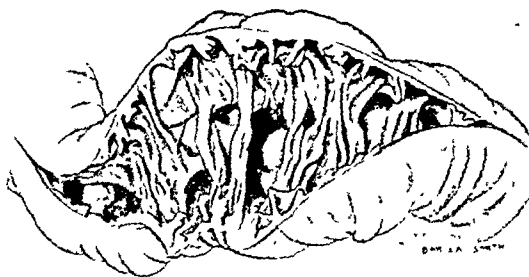


FIG. 397.—Case 2. Portion of the specimen laid open along the antimesenteric border, showing towards the left a pair of diverticula, one on each side of the mesenteric border; in the centre two such diverticula have fused into one larger one.

and none of them contains faecal contents; it is noteworthy that none of the diverticula related to the inflammatory mass outside the intestine show any ulceration or gross inflammation of the mucous membrane lining them, and in this respect the case resembles that recorded by Butler (No. 7 below); there is no sign of necrosis or perforation. Microscopical examination of the mass showed it to be entirely inflammatory, the connective tissue being infiltrated by polymorphonuclear cells, and the wall of the abscess lined by granulation tissue. From the clinical standpoint it is interesting that this patient

complained of no symptoms until 48 hours before her operation, yet at the time she had a well walled-off intraperitoneal abscess of considerable size, and it seems incredible that this should have formed in so short a time without giving rise to spreading peritonitis.

adjacent mesentery, but this swelling was sharply defined, and its firm consistence suggested the presence of a tumour. In the root of the mesentery corresponding to this loop, but separated from the inflamed area by apparently healthy mesentery, was

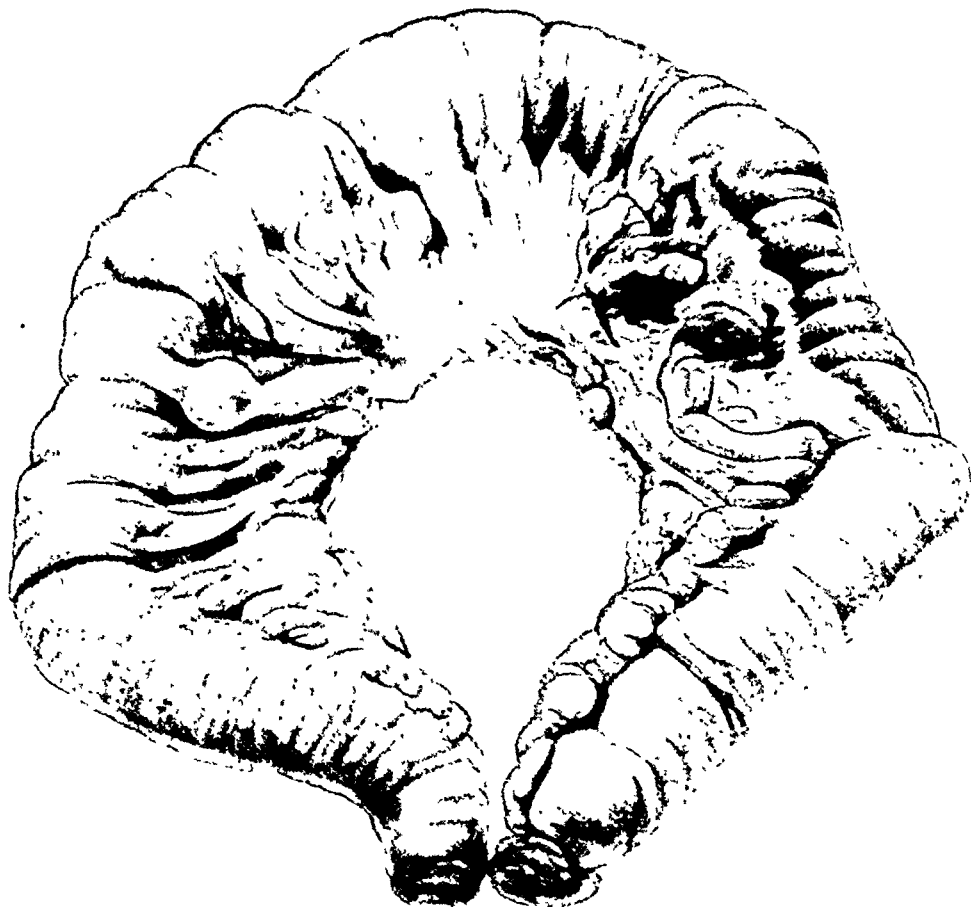


FIG. 398.—Case 2. The specimen removed at operation. Note area of inflammation of the mesentery, where the latter formed part of the wall of the abscess.

**Case 3.**—This example falls into a rather different category, in that the diverticulum was situated in the lower ileum, but reasons will be given later for concluding that it also is an acquired mucous membrane hernia type of diverticulum.

A married woman of 53 was seen in consultation with Dr. A. V. Russell on April 27, 1938; she complained of abdominal pain for 36 hours, and vomited after the onset of the attack; the pain was at first generalized, but later settled in the right lower quadrant—in fact, she gave a typical history of acute appendicitis. She had had no previous similar attack, but there had been mild indigestion associated with diarrhoea for some months. Her temperature was  $101^{\circ}$ , pulse-rate 120, and the lower abdomen was tender and rigid.

**AT OPERATION.**—A little free fluid was present in the peritoneal cavity; the appendix, which was adherent but not acutely inflamed, was removed; the lowest loop of ileum, from 7.5 cm. to 15 cm. from the ileocaecal valve, was oedematous and covered with fibrin; the oedema spread some way into the

a small calcified lymph-node, but there was no fibrosis round the node to suggest any traction on the intestine. The inflamed portion of ileum was excised and end-to-end union carried out, and she made a satisfactory recovery.

She was seen again in July, 1941, over three years after her operation; there had been no further abdominal symptoms, and a barium meal showed no evidence of abnormality in the small intestine.

**THE SPECIMEN (Fig. 399).**—This consists of 11 cm. of the ileum and adjacent mesentery. When opened along the antimesenteric border, towards the distal end was seen the small orifice of a diverticulum from which a little pus escaped; section through the wall of the ileum showed that the diverticulum lay between the layers of the mesentery, immediately outside the muscular coat of the intestine; it was 1 cm. in diameter, and almost filled by a faecal concretions, surrounded by a thin layer of pus. The lining was markedly inflamed, and oedema spread out into the surrounding mesentery. Microscopic examination showed no evidence of a muscular coat

but a lining of granulation tissue, with no trace of mucosa now remaining.

**Comment.**—Some doubt may be expressed as to whether this is a true mucous membrane pulsion hernia, similar in aetiology to those found in the jejunum and colon. In appearance it bears a very close resemblance to diverticula



FIG. 399.—Case 3. The portion of ileum resected. The diverticulum has been laid open, and a glass rod inserted through the orifice by which the diverticulum communicated with the lumen of the intestine. Note the inflammation around the orifice, and oedema of the surrounding mucous membrane.

of the colon, and there is every reason to believe that, as the consistency of the contents of the small intestine change in passing downwards, so the type and complications of these diverticula will approximate to those found in the large intestine.

#### CASES IN THE LITERATURE

The previously recorded cases of diverticulitis in the small intestine, excluding the duodenum, are so diverse in their manifestations, that it is thought necessary to give a summary of all these 19 examples.

1. GORDINIER AND SAMPSON (1906).—F., 45. Acute inflammatory attack treated conservatively; operation 2½ months later; 13 diverticula present in lower jejunum or upper ileum, one having its base occluded forming a cyst; scarring caused subacute obstruction. Cyst excised and adhesions freed. Recovery.

2. CHRISTIE (1922).—F., 48. Acute attack treated conservatively; operation 14 days later; perforation at fundus of jejunal diverticulum 9 in. from duodeno-jejunal flexure, on antimesenteric border, was sealed by omentum; excision of diverticulum and lateral anastomosis. Recovery.

3. SPACKMAN (1926).—M., 75. Acute attack; two inflamed jejunal diverticula found; resection 6 in. of jejunum. Died.

4. SIMONS (1928).—M., 57. Acute attack of abdominal pain; 2 ft. of jejunum distended and cyanotic, and containing diverticula; no peritonitis or perforation. No resection undertaken; recovery.

5. GOINARD AND COURRIER (1929).—F., 61. Signs of intestinal obstruction; at operation acutely inflamed jejunal diverticula; no resection; death. At autopsy, diverticula found to contain ova of *Strongyloides intestinalis*.

6. FRASER (1933).—F., 30. Operation on third day of acute attack; many diverticula in upper jejunum, one being acutely inflamed and perforated; the inflammation caused kinking of the intestine and obstruction. Resection 4 ft. of jejunum. Recovery.

7. BUTLER (1933).—F., 72. Operation first day of attack; acute inflammation at the base of a jejunal diverticulum, the inflammation being most marked on the peritoneal surface, and the mucous membrane showing only slight evidence of inflammation; resection of 2 ft. Recovery.

8. BUTLER (1933).—M., 56. Operation 12 hours after onset of acute attack; 1 ft. of upper jejunum inflamed, five diverticula present, one of which had perforated. Resection; death from paralytic ileus.

9. BUTLER (1933).—M., 64. Laparotomy on second day of attack; peritonitis, upper 18 in. of jejunum inflamed, but diverticula extended for several feet beyond. No perforation; pus evacuated and wound closed; recovery.

10. BUTLER (1933).—F., 72. Operation 36 hours after onset; one of seven diverticula in upper jejunum had a perforation at its base with local abscess, and inflammation of the mesentery. Resection: died from uræmia.

11. FLYNN (1933).—M., 49. Acute abdominal symptoms for 36 hours; previous acute attack eight weeks before. Perforated diverticulum 15 cm. below duodenojejunal flexure. Resection 45 cm. containing diverticula; recovery.

12. VAN NOORT (1935).—F., 31. Two days' history; two diverticula present, one inflamed and covered with fibrin "threatening to perforate". Resection; recovery.

13. GERSTER (1938).—M., 51. Operation 11 hours after onset; diffuse peritonitis; nine diverticula in upper jejunum, the lowest inflamed and covered with fibrin, but not perforated. Drainage; died of uræmia.

14. HUBENEY AND POLLACK (1938).—F., 63. Acute inflammatory attack treated conservatively; multiple fluid levels demonstrated radiologically; operation 17 days later revealed diverticula from 2 to 15 cm. diameter, throughout the small intestine; one in left lower quadrant was adherent to an adjacent loop of small intestine causing partial obstruction; the adhesion was freed, but no resection undertaken; the patient died three months later, but cause of death was not ascertained.

15. LARSON (1938).—F., 57. Acute attack treated conservatively at first, but showed no signs of subsiding, so operation undertaken; diverticula were present from 8 in. to 55 in. from the duodenojejunal flexure; 55 in. containing 64 diverticula resected; recovery. The wall of the gut is described as thickened and oedematous, the inflammation not being confined to particular diverticula; microscopically, a few areas showed round-celled infiltration.

16. EDWARDS (1939).—M., 53. Acute inflammatory attack; operation revealed a single diverticulum about the middle of the small intestine, which was acutely inflamed, the mucous membrane having sloughed, and the lumen occupied by pus. Resection and complete recovery.

17. DODSON (1941).—F., 62. Operation seven days after onset of attack; abscess round a perforated diverticulum had ruptured into the general peritoneal cavity; the operative procedure is not given, but recovery took place, the patient eventually succumbing to coronary thrombosis seven years later.

18. KOLETSKY (1941).—M., 50. Acute inflammation of a diverticulum of the ileum 1.5 cm. from the ileocaecal valve with perforation and a localized abscess; the abscess was drained, but the patient died; numerous diverticula were also present in the caecum and ascending colon.

19. OVENS (1943).—F., 59. General peritonitis due to inflamed but not perforated jejunal diverticulum. Upper 8 ft. of jejunum contained diverticula. Resection 8 in., including the inflamed diverticulum; recovery.

It will be seen that there is a strong tendency to perforation, which is surprising in view of the wide drainage which is usually available into the lumen of the intestine; when perforation does not take place, there is a risk of spreading peritonitis, which may become generalized, or may localize with abscess formation. In the latter case, adhesions may form which sometimes cause intestinal obstruction subsequently. As in the first case here reported, the symptoms of the acute attack may be mainly those of acute intestinal obstruction, the inflammatory oedema of the wall of the intestine being sufficient to bring this about. Often the inflammation is confined to a single diverticulum and its immediate neighbourhood, but Cases 4, 9, and 15 are instances of a more diffuse inflammation where several inches of the intestine are involved with equal intensity throughout this length.

In all the above cases except Case 18, and perhaps Cases 1 and 16, it was the jejunum which was the site of the diverticula. Edwards expresses some doubt about the nature of his case, and considers that it may have a congenital origin for the following reasons: (1) Its situation, probably lower jejunum or upper ileum; (2) It had a thin muscular coat at the fundus; (3) It communicated with the lumen of the intestine by a very narrow opening; and (4) It stood a little way from the wall of the intestine. In spite of the doubt of its origin it is included in the above table, as from the clinical standpoint it falls into this group of acute diverticulitis. It is in comparison with this that a critical study of the present writer's Case 3 is made, as superficially the two have a close resemblance; in both the diverticulum was situated lower down the bowel than is usual, and both communicated with the lumen by a narrow orifice; the absence of a muscular coat, and its similarity to acquired diverticula as they occur in the adjacent ascending colon convince the writer that the case here described is a mucous membrane hernia type of diverticulum.

The only other example of a diverticulum of the ileum becoming inflamed is Case 18. Here the data are incomplete as the report does not give the relation of the diverticulum, which was

1.5 cm. from the ileocaecal valve, to the mesentery, and it was too necrotic to identify the layers of its wall; clinically it falls into line with the other cases of the group, and emphasizes that the nearer the colon is approached, so the diverticula approximate pathologically to those found in the colon.

Acute diverticulitis is therefore the most common complication of diverticulosis of the jejunum-ileum; there is a strong tendency for it to give rise to spreading peritonitis; and, though the diagnosis is unlikely to be made before operation, surgical intervention is urgently called for, and resection of the affected portion of the intestine is the treatment of choice. Note is made of the fact that peritonitis and inflammation in the mesentery may occur without any gross changes in the lining of the diverticulum.

A case is recorded (Dodson, 1941) in which acute intestinal obstruction was caused by a band running from a solitary diverticulum 16 in. below the duodenojejunal flexure to the mesentery; there was a previous history of dyspeptic symptoms for three months, but no evidence of an acute attack. Excision of the diverticulum was carried out and recovery with relief of dyspeptic symptoms followed.

Before passing on to the other complications, a case recorded by Verster (1941) deserves mention as it presents many unusual features: The patient was a girl of 21, who had had symptoms since the age of 8; she was very emaciated, and had visible peristalsis; the upper 4½ ft. of jejunum containing 20 diverticula were removed, and three adhesions, presumably the cause of the obstructive symptoms, were divided; it is doubtful whether the diverticula were in any way the cause of her symptoms, which may have been entirely due to the adhesions, but the possibility that the partial obstruction was a contributory factor in the development of the diverticula, a suggestion originally put forward by Astley Cooper, cannot be excluded; their presence at this age, however, is unique.

## 2. CONCRETION FORMATION

Four examples of this complication are on record, in addition to the Case 3 described above, in which both diverticulum and concretion were small; in three of these cases acute intestinal obstruction supervened.

1. CHRIST (1932).—Man, 60. Obstruction of the ileum by a concretion 6 × 4 × 3 cm. displaced from a jejunal diverticulum. Removal of the concretion and recovery.

2. WATSON (1924).—Man, 73. Concretion, size of a walnut, in a jejunal diverticulum, causing partial obstruction by its encroachment on the lumen of the intestine; excision of concretion, and recovery.

3. TERRY AND MUGLER (1921).—Female, 59. Concretion from a diverticulum causing obstruction by filling the lumen of the jejunum; the concretion was broken up without opening the intestine, and its fragments subsequently passed per rectum; she recovered.

4. RENAUD (1921).—Female, 62. When operating for a pyloric ulcer multiple jejunal diverticula were observed, and the largest, described as being the size of a nut, 4 cm. from the duodenojejunal flexure, and containing a concretion, was excised. The concretion was of soft consistence.

It is noted that in no case of jejunal diverticulitis has a concretion been found in the diverticulum, suggesting that such concretions do not predispose to inflammation; this statement is probably not equally true of the ileum. The fact that concretions large enough to obstruct the bowel can emerge from jejunal diverticula is consistent with the anatomy of such diverticula which usually have wide necks, but it is not so easy to explain the force which causes them to be extruded from the diverticula, as the latter as a rule have no muscular coat in their walls except a very attenuated muscularis mucosæ.

### 3. HÆMORRHAGE

Sudden severe hæmorrhage may occur from a jejunal diverticulum, as may arise from diverticula in certain other situations, e.g., the bladder. Examples have been recorded by:—

1. BRAITHWAITE (1923-4).—Man, 54. Five pints of blood were vomited on one occasion; he had other symptoms, and at operation multiple jejunal diverticula were found.

2. GUTHRIE AND HUGHES (1937).—Man, 54. Several large hæmorrhages which required a blood transfusion; diarrhoea, and passage of mucus were the only other symptoms; resection of 19 in. of upper jejunum containing 22 diverticula.

3. TENGWALL (1931).—Female, 49. Hæmorrhage was the chief symptom; resection of 50 cm. of jejunum containing multiple diverticula.

The blood may be vomited as in the first example, or passed by the rectum as in the last two.

### 4. TRAUMATIC RUPTURE

The only example of this complication is recorded by Butler (1937).

This case was a man of 41, who had been kicked in the abdomen by a cart mare four hours before the operation was undertaken. A ruptured jejunal diverticulum with pouting mucous membrane was found and sutured, two other diverticula being noted; he died 10 hours later, and at the autopsy a second perforated diverticulum immediately distal to the duodenojejunal flexure was found.

### 5. VOLVULUS

Volvulus in association with diverticula of the small intestine has been described twice:—

1. GODARD, BOURDIAL, AND ZOUREKATIS (1932).—F., 39. Operation for acute intestinal obstruction, when a volvulus of an upper loop of jejunum was found. Reduction and resection of 28 in. of jejunum containing all diverticula then present. Five years later there was epigastric pain, and radiography and laparotomy revealed new diverticula in upper 3 ft. of jejunum; further resection and recovery.

2. STIVEN (1934).—M., 40. Attacks of colic, constipation, and vomiting for three years; barium meal precipitated acute intestinal obstruction; diverticula were found to be present throughout the jejunum

and ileum. Volvulus was caused by the interlocking of a diverticulum of the ileum the size of a hen's egg, with a similar sized diverticulum high up in the jejunum. Their twisted necks formed a band over which another loop of small intestine was kinked and formed the volvulus. The organs were untwisted, but no resection performed, and recovery took place.

The precise mechanism by which the volvulus was formed in the first place is not given, but the train of circumstances which produced it in the second example must verily have been a chapter of accidents.

The possibility of malignancy as a complication has not been mentioned; there is only one example in which the two conditions coexisted, reported by Edwards (1939), and in this case it is not certain that the tumour which was situated at the margin of a diverticulum was the primary malignant growth. The evidence is not sufficient to justify any assumption that diverticulosis of the small intestine predisposes to carcinoma.

Miss Barclay-Smith kindly undertook the illustration of the specimens, and I take this opportunity of expressing my gratitude to her.

### REFERENCES

- BRAITHWAITE, L. R. (1923), *Brit. J. Surg.*, 11, 184.  
 BUTLER, R. W. (1933), *Ibid.*, 21, 329.  
 — (1937), *Ibid.*, 25, 277.  
 CHRIST, A. (1932), *Dtsch. Z. Chir.*, 236, 560.  
 CHRISTIE, G. W. (1922), *Brit. med. J.*, 1, 990.  
 DODSON, R. M. (1941), *West. J. Surg.*, 49, 143.  
 EDWARDS, H. C. (1939), *Diverticula and Diverticulitis of the Intestine*. Bristol: John Wright & Sons.  
 FLYNN, R. (1933-34), *Aust. N.Z. J. Surg.*, 3, 192.  
 FRASER, I. (1933), *Brit. J. Surg.*, 21, 183.  
 GERSTER, J. C. A. (1938), *Ann. Surg.*, 107, 783.  
 GODARD, H., BOURDIAL, and ZOUREKATIS, TH. (1932), *Ann. Anat. path. méd.-chir.*, 9, 311.  
 GOINARD, P., and COURRIER, R. (1929), *Ibid.*, 6, 189.  
 GARDINIER, H. C., and SAMPSON, J. A. (1906), *J. Amer. med. Ass.*, 46, 1585.  
 GUTHRIE, D., and HUGHES, F. A. (1937), *Surgery*, 1, 595.  
 HUBENEY, M. J., and POLLACK, S. (1938), *Amer. J. Roentgenol.*, 40, 689.  
 KOLETSKY, S. (1941), *Ohio St. med. J.*, 37, 1078.  
 LARSON, E. M. (1938), *West. J. Surg.*, 46, 127.  
 OVENS, G. H. C. (1943), *Brit. J. Surg.*, 30, 239.  
 RANKIN, F. W., and MARTIN, W. J. (1934), *Ann. Surg.*, 100, 1123.  
 RENAUD, M., and BERGERET (1921), *Bull. Soc. anat. Paris*, 18, 220.  
 ROSEDALE, R. S., and LAWRENCE, H. R. (1936), *Amer. J. Surg.*, 34, 369.  
 SIMONS, E. J. (1928), *Minn. Med.*, 11, 752.  
 SPACKMAN, J. G. (1926), *Ann. Surg.*, 84, 778.  
 STIVEN, H. F. S. (1934), *Lancet*, 2, 704.  
 TENGWALL, E. (1931), *Acta. chir. scand.*, 68, 162.  
 TERRY, W. H., and MUGLER, R. R. (1921), *Arch. Surg.*, 2, 347.  
 VAN NOORT, D. W. (1935), *Ned. Tijdsch. Geneesk.*, 79, 5232.  
 VERSTER, R. S. (1937), *S. Afr. med. J.*, 11, 838.  
 WATSON, C. M. (1924), *Surg. Gynec. Obstet.*, 38, 67.

## CONSERVATION OF THE METACARPUS BY SKIN AND BONE GRAFTING IN THREE PATIENTS

BY SURGEON COMMANDER P. B. MORONEY, R.N.V.R.

THESE three patients afforded opportunity to conserve a metacarpus as an entity conferring some enlargement of residual function in hands

control of sepsis, and discounts bony reconstruction technically easier than restoration of integument after extensive loss.

### CASE REPORTS

**Case 1.—Degloving by avulsion—immediate femoral skin-flap.**—On Dec. 11, 1936, N. A., a printer, was admitted to hospital two hours after injuring his right hand in the press. The mid, ring, and little fingers had been avulsed while the stumps with the metacarpus, back and front, from the level of the ulnar styloid to the root of the index finger, were denuded of integument. On the palmar surface separation was in the plane of the palmar fascia, while in the dorsum tendon and bone were exposed. The dorsal defect is shown in Fig. 400, inset. In the hand the total skin defect measured approximately 11 sq. in. and was of semicircular shape on a diameter passing through the metacarpal heads, centering on that of the fifth. The wound was macroscopically clean and immediate restoration of the integument appeared to be indicated.

Operation, performed four hours after injury, included a conservative surface débridement and disarticulation of mid and ring finger stumps, sewing the tendons over the metacarpal heads. The stump of the little finger was retained for inclusion in a lateral femoral flap, which was next fashioned and sewn to the dorsal defect.

FIG. 400.—Case 1. Degloving by avulsion. Palmar loss mirrored the dorsal defect (inset). Final appearance of femoral flap.

threatened by hemi- or sub-total amputation following severe injury. The functional desiderata of length, breadth, strength, and mobility are well illustrated in the instance of a bricklayer, quoted by Griffiths (1935), who continued his avocation for twenty-eight years after the loss in one hand of all digits except the thumb. After injury by the familiar mechanisms of avulsion, crushing, or burning, the critical reparable deficiency is integument, and on its restoration most attention has been focused. From the literature it is not readily apparent that bone-grafting may be complementary to skin-grafting in the attainment of these limited objectives; for no case of traumatic metacarpal pseudo-arthritis could be discovered in two decades subsequent to 1919. During the last war it was frequent, an incidence of 30 per cent in three hundred war fractures of the metacarpus being given by Saxl (1915). The inference must be that bone defects of the metacarpals are exclusively due to projectiles. For the treatment of "les grand broiments du squelette metacarpien" Tuffier advised high amputation in the neighbourhood of the carpus. Routine execution of this teaching must frequently sacrifice viable tissue, does not take account of chemotherapeutic

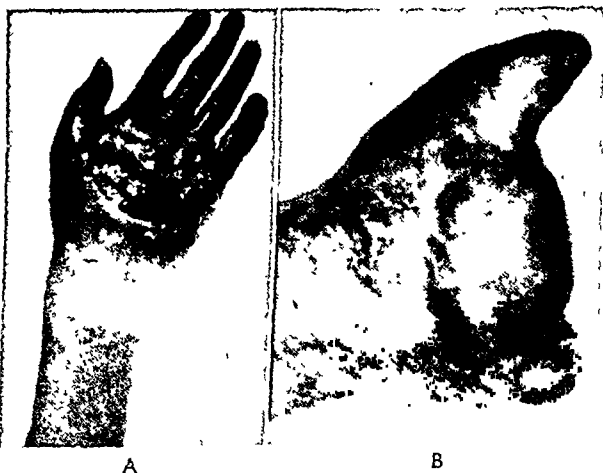


FIG. 401.—Case 2. A, Laundry roller gangrene 31 days after injury, B, Inferior epigastric flap used to maintain length of metacarpus.

This flap hung posteriorly and wrapped round the hypothenar eminence for 1 in. There remained a triangular area of the central palm and the donor area

to which Thiersch grafts on perforated oiled silk were applied and moist wool moulded over them. Pronating the hand into contact with the thigh enabled light pressure applied through further dressings on the dorsum to be maintained on the three planes of grafts. There was no local or general flare, but only a portion of the free grafts took and on the forty-third day these were repeated. The hinge of the pedicle was not detached until the twenty-ninth day. Nine weeks after admission he was discharged with a healed hand.

Following-up, litigation delayed re-employment, but on returning to his previous trade the loss of the

hence disarticulation was not considered adequate. Utilizing a long palmar flap of viable skin from the little finger and a single hinged abdominal flap, the defect in integument was closed. About a third of the little finger flap sloughed and was excised; the hinge of the pedicle was detached on the thirteenth day and the donor area approximated. There was a temperature of 100° for three days, for which 10,000 units of anti-gas-gangrene serum and sulphanilamide were given. Local reaction was slight. He was repatriated three months after admission and the appearance at that time is shown in Fig. 401, B.

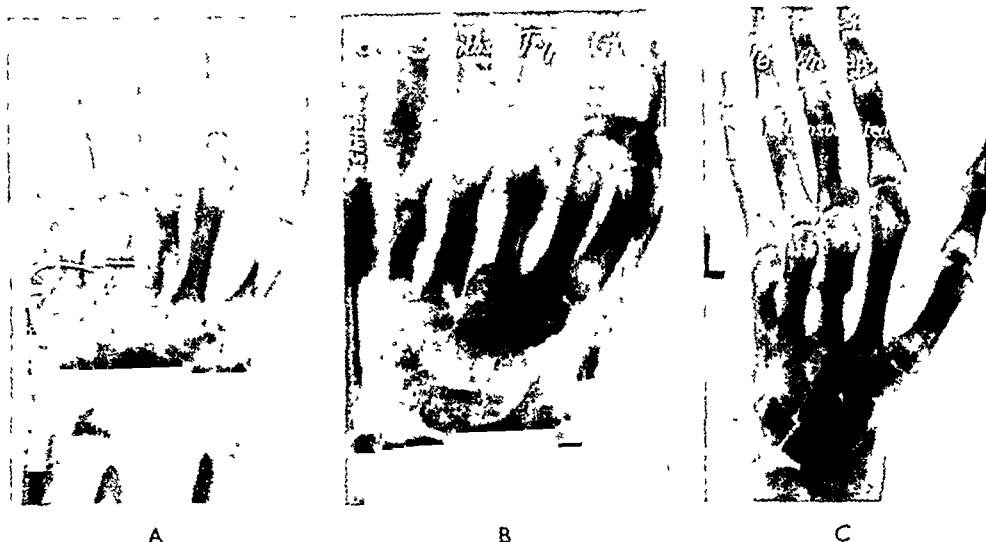


FIG. 402.—Case 3. A, Pseudo-arthritis of third, fourth, and fifth metacarpals, five months after injury by shell fragment; B, Albee bone-grafts; C, Consolidation and remodelling 16 months after operation.

fingers impaired dexterity and he finally became an insurance agent. The appearance of the hand a year after injury is shown in Fig. 400. Although cosmetically the free grafted area is inferior, no functional troubles have ensued up to seven years. An excellent caligraphy due to the stabilizing function of the ulnar border of the hand, better power, and an enhanced cosmetic result *vis-a-vis* hemi-amputation perhaps justified hazards nowadays reduced by the advent of chemotherapy.

The femoral donor area was chosen in order to secure counter-pressure for free grafts necessary for immediate closure of the semicircular defect present on both surfaces of the hand.

**Case 2.—Laundry roller gangrene—late abdominal flap.**—An American merchant sailor, N. A. J., caught his right hand between steam-heated laundry rollers. Six days later he was admitted to an R.N. hospital on Dec. 12, 1941. Four fingers and half a thumb were mummified, but moist superficial scalds were present on the palmar eminences. These were treated with triple dye until healed. A line of demarcation was present on admission, half an inch behind the metacarpal heads, and during the twenty-five days prior to operation dorsal integument retracted farther, to leave a granulating area which remained healthy (Fig. 401, A).

At operation (performed without tourniquet), bone section was made at the level of the line of superficial demarcation. Cartilage on the metacarpal heads was soft and degenerate with early eburnation,

**Comment.**—Pressure combined with scalding probably determined mass gangrene at the same level in all tissues. Scalding by contact with one roller inflicted only minor damage in the proximal palm, although the duration of such contact may have been only momentary.

**Case 3.—Pseudo-arthritis of 3rd, 4th, 5th metacarpals due to shell fragment—treated by triple Albee bone-graft.**—R. S. sustained by enemy action (shell fragment) a dorsal wound of the left hand causing 1 sq. in. loss of integument and gross comminution with loss of substance in the inner three metacarpals. There was no exit wound. He was admitted eight days after injury to an R.N. hospital. The interphalangeal joints of the affected fingers retained some active movement, but active extension at the knuckles was lost owing to solution of the extensor tendons. There was no gross infection at any time.

The skin wound healed under plaster, which was maintained for three months without traction in order to retain mobility in the distal joints. Retraction of the knuckles had increased during this period and the fracture remained ununited clinically and radiologically. For a further two months wax baths and exercises were given without 'flare.' His disability had then two main components: impaired function of three fingers due to stiffness at the knuckles; and weakness and pain in the hand, which was almost flail, preventing him lifting light articles. It was decided to do a triple Albee bone-graft for



the metacarpal pseudo-arthritis, which was performed through two incisions. The non-union in the mid, third, metacarpal was a fibrous one between two half-thickness fragments. To these, without exposure or curettage of the ends a graft was applied. In the case of the fourth and fifth scar tissue was excised and V-shaped slots prepared to receive grafts cut over length in order to add bone to the gap and provide fixation by distraction after seating the donor bone. There was only slight post-operative reaction.

After twelve weeks of fixation in plaster down to the proximal interphalangeal joints, union was strong. At a subsequent operation the dorsal scar was excised and an intermediate thickness skin-graft applied. Six months after bone-grafting, eleven after injury, he was discharged to his limited duties. Serial radiographs (Fig. 1, 2, 3, 4) show the bone defect, the shape of the grafts, and final consolidation with remodelling.

### DISCUSSION

The size of the hand is threatened mainly by loss of integument counselling high amputation and its early restoration is essential to conservation (McIndoe, 1943; Brown, 1938). The magnitude of the initial deprivation eliminated complicated glove-flap repair (Colt, 1927; O'Connor, 1936) and choice of technique rests between free and single-hinged pedicle grafting. For defects exceeding 1.5 sq. cm. free transplants were reported in the primary treatment of a large series of 207 cases by the Russian, Gofren (1937). For permanent repair, a pedicled flap is favoured by most British and American writers, particularly in avascular or functionally important areas.

Large central bone defects undermine the static strength of the hand and by Albee technique this may be restored. Medullary blood-supply reinforced by a cortical one via the interosseous musculature and two major palmar anastomoses provide a site favourable to a take.

Mobility of the metacarpus is less readily achieved and is dependent upon the extent of

soft-tissue damage, the absence of sepsis, and the time interval elapsing after injury and grafting: when absence of damage to flexor tendons envisages the greater functional objective of useful digital function, the advantage of early bone-grafting may perhaps be mooted. Many months of prolonged traction on fingers or double skeletal transfixion of the metacarpal fragments to prevent retraction of the knuckles are likely to induce stiffness, and late bone-grafting, still necessary to bridge gaps, cannot aspire to more than restoration of static strength of the hand.

### SUMMARY

1. The intrinsic functional value of the metacarpus and methods employed to conserve it after severe injury in three cases are described.
2. In the metacarpus the suggestion is made that early bone-grafting would enhance the functional end-result in suitable cases.

For permission to publish two of these cases I am grateful to the Medical Director-General of the Navy, and to Surgeon Rear-Admiral R. F. P. Cory and H. M. Whelan and Mr. S. N. Taylor I wish to express my thanks for facilities so kindly granted.

### REFERENCES

- ALBEE, F. H., *Bone-graft Surgery in Injury, Deformity and Disease*. New York: Appleton-Century Co.  
 BROWN, J. B. (1938), *Ann. Surg.*, **107**, 952.  
 COLT, G. H. (1927), *Brit. J. Surg.*, **14**, 560.  
 GOFREN, A. C. (1937), *Kirurgiya*, **3**, abs. *Zent. Org. Chir.* 1938, **89**, 354.  
 GRIFFITHS, H. E. (1935), *Injury and Incapacity*, 183. London: Baillière, Tindal & Cox.  
 MCINDOE, A. H. (1943), *Proc. R. Soc. Med.*, **36**, 647.  
 O'CONNOR, G. B. (1936), *Amer. J. Surg.*, **32**, 445.  
 SAXL, A. (1915), *Wien. klin. Wschr.*, **28**, 1438.  
 TUFFIER (1919), *Arch. Méd. Pharm. milit.*, **71**, 541.

## OSTEOMYELITIS OF THE CLAVICLE

By TINA GRAY

LATE HALL TUTORIAL FELLOW, UNIVERSITY OF GLASGOW

OSTEOMYELITIS of the clavicle is a sufficiently rare condition to warrant recording the following case, which has also the unusual feature of practically complete regeneration of the clavicle from the periosteum after removal of the diseased bone.

### CASE REPORT

A. R., a delicate looking little boy of 12, was admitted to the Glasgow Royal Infirmary on May 22, 1943. He had first attended the Out-patient Department on May 8 complaining of pain and slight swelling over the left clavicle after a tumble while playing leap-frog. A fracture was suspected, but a radiograph showed a normal clavicle.

At that time there were no constitutional disturbance, no reddening of the skin, nor raising of the

local temperature, but on his second visit obvious signs of abscess formation were present. It was opened and pus evacuated. The radiograph taken that day showed well-marked destruction of the acromial third of the clavicle (Fig. 403, 1).

He remained under the care of his own doctor, with instructions to report a week later. His condition had deteriorated by then and he was admitted to the wards, when I saw him for the first time. He looked ill, his temperature was raised, the area over the clavicle was swollen, red, fluctuant, and painful to touch, with only a little pus coming from the incision.

He was taken into the theatre and under gas and oxygen anaesthesia the incision was enlarged. Immediately this was done the sternal end of the clavicle protruded from the opening along with the pus, and I was able to lift the whole bone from its bed as if it had been



FIG 403.—Radiographs showing. 1, The condition before operation; 2, Some days afterwards  
3, 4, Two stages of regeneration.

a foreign body (*Fig. 404*), leaving a pus-filled, clavicle-shaped cavity lined with congested velvety granulations. The pus was mopped out and the cavity packed with tulle gras and sulphapyridine powder. The boy's further progress gave no cause for anxiety, except for the probable loss of function. However, it was evident in a few days that this would be minimal as

back to school with no disability (*Fig. 405*). When seen on Dec. 6 the wound was sound, with no evidence of breaking down.



FIG 404.—Showing the inferior surface of the clavicle after removal.

he moved his arm freely in all directions and there was no dropping of the shoulder in repose. He was X-rayed again on May 28, and already a few irregular opacities suggested commencing regeneration of bone (*Fig. 403, 2*). He went out to the County Orthopaedic Hospital, Stonehouse, for convalescence on June 11. By that time there was palpable formation of bone at the acromial end and a narrow line of superficial granulations represented the wound, with a little pus coming from a slightly deeper infection at the mid-point. On July 1 the X-ray films showed commencing moulding of the new clavicle (*Fig. 403, 3*). By Aug. 18 the wound was healed and the child went home and



FIG. 405.—Photograph showing lack of deformity and range of movement.

While in Stonehouse Hospital he was on Multivite tablets, Irradex, and Ostelin Cream or calcium tablets.

I wish to thank Mr. G. T. Mowat for permission to publish the case and Dr. Gibson for the photographs.

## OBSTRUCTIVE APPENDICITIS

By W. H. BOWEN, CAMBRIDGE

OBSTRUCTIVE appendicitis is the name given to that type of appendicitis in which obstruction of the lumen is associated with distension of the coats of the viscus, distal to the obstruction, by exudate which may be mucus or mucopus, and if the latter may be mixed with faecal material. An inflammatory attack is probably the primary cause, the obstruction being secondary. The blockage of the lumen is most commonly due to a stercolith or scybalous mass, but other causes are recognized, as will be pointed out later. The distension of the coats leads to nutritional changes which ultimately result in necrosis of the distended portion.

In 1914 Wilkie called attention to the pathological picture and in some experimental work showed the gravity of the condition. He segregated a loop of the lower ileum and re-established the continuity of the small bowel. The segregated loop became distended, the wall necrosed, and infection of the peritoneal cavity resulted. Wilkie gave the two common causes of obstructive appendicitis as (1) fibrous stenosis, (2) acute kinking. He found that a much more rapid necrosis set in if faecal material was milked from the caecum into the segregated loop before this was finally isolated. He concluded that "the attack of acute obstruction is probably excited by access of faecal material to the distal part of the appendix beyond the kink".

Behan (1921), working along much the same lines in rabbits, but directly on the appendix itself, came to the conclusion that partial occlusion in rabbits does not cause appendicitis even though faecal material collects in the part distal to the partial occlusion.

It is thirty years since Wilkie's paper was published. In this time it has been possible to collect and analyse cases of obstructive appendicitis, to compare them with other types of the disease, to discuss the incidence and the causes, and to consider some problems which arise out of a study of the subject.

In considering the incidence an analysis of two lots of cases, one of 150 the other of 357, has been made. In the former there were 19 cases, in the latter 51. We may conclude that the percentage of cases of obstructive appendicitis (only acute disease is being considered) is somewhere about 13 to 14 per cent. This percentage of cases is only approximate, since it deals with cases found at operation where abscess formation has not resulted. Abscess formation is due to other causes than obstructive appendicitis, so that where an abscess has formed it may be impossible to say whether it is due to obstructive appendicitis, perforation, or lymphatic spread. The error must be very small.

As to the origin of the obstruction an analysis of 38 cases can be given, a consecutive series covering a period of eleven years. The following table is the result:—

Total number of cases: 38.

a. Stercolith	21 (55.3 per cent)
b. Stenosis	1 (2.6 per cent)
c. Kinks and bends (all whorls)	4 (10.5 per cent)
d. Spasm (no stercolith, kink, or bend)	12 (31.5 per cent)

Leaving the stercolith for fuller consideration later, attention may be called to the rarity of stenosis as a cause of acute obstructive appendicitis. It is, however, probably the commonest cause of the chronic form which results in a mucocele of the appendix. No kink was found which could be looked upon as obstructive. Hairpin bends of the appendix, bands binding the appendix to the iliac fossa, and other attachments are found without evidence of disease or stagnation beyond the kink or bend. Whorling of the appendix, a corkscrew-like spiral, given under group c, is a concession, and should probably be put under group d, since it is a not uncommon condition, is almost invariably not the result of disease being congenital in origin, and may be compared with a Lane's ileal kink, which is more often than not unassociated with constipation. Sadyoun and Oppenheimer (1939), whose work will be referred to later, are quite definite that kinks and bends do not prevent the evacuation of the normal appendix. A series of X-ray pictures will convince the sceptic on this point.

The fact that obstructive appendicitis may be found at operation without stercolith, stenosis, or kinking is not generally recognized. It will be noted that the absence of any gross obstructive factor is found in over 31 per cent of all cases. This is difficult to explain save on the hypothesis of a local spasm. It cannot be due to a stercolith which has later been forced out, for obviously a muscular tube capable of expelling a stercolith would be more than capable of clearing out any softer material distal to it.

Before discussing the significance of faecal stasis as a factor in the aetiology of obstructive appendicitis it is advisable to consider the significance of the stercolith in appendicitis. It is now generally recognized that it is the aetiological factor in the severe forms which lead to gangrene. In 61 cases of acute catarrhal\* appendicitis a stercolith was present in but 5 per cent, whereas in 66 cases where gangrene of the appendix was present, usually involving all coats (90 per cent), a stercolith was present in 63 per cent.

\* By catarrh is meant acute congestion, however variable in degree, unassociated with gangrene or obstruction.

The stercolith, however, does not, in the majority of cases, lead to obstructive appendicitis but to gangrene, local or diffuse, usually in the area of the stercolith, often distal to it in addition, very rarely indeed proximal to it. Such local gangrene in the area of the stercolith usually results in perforation. Comparing the cases of appendicitis with gangrene in which a perforation actual or potential was present with those causing obstruction, the ratio is roughly 4 to 1. In other words, in close on 80 per cent of cases where a stercolith is present there will result not obstruction but local gangrene leading to perforation. The stercolith varies in consistency, and whilst some are little more than small scybala others are stony hard. When found by chance or early in an attack of appendicitis they may be quite mobile. Occasionally in an obstructive case of appendicitis a stercolith capable of causing the obstruction may be found floating in the fluid. In such cases I have looked upon this stercolith as the active factor, as this seemed reasonable, but its position does suggest that something after removal released the stercolith and makes one think of a spasm relaxing.

Every phase of the sequence from faecal matter to hard stercolith can be recognized in a series of cases and there is every reason to believe that the stercolith is a slow formation and that its potentialities, physical or infective, have been present for weeks. It would be interesting to have some systematic post-mortem records on this point. In a very limited experience and dealing only with cases of sudden death where slow wasting and functional weakness can be eliminated, one case of stercolith has been seen. This was in a boy 10 years old, who died soon after a severe head injury. Two stony hard stercoliths, each the size of a split pea, were found. They were mobile. Otherwise the lumen was empty. There was no kink, bend, or narrowing. In other cases of sudden death faecal accumulations of varying amount have been found without congestion of the mucous membrane underneath. The total number of post-mortems with full records for reference were only 12 in number and the stercolith and faecal accumulations having been found without evidence of active disease, the investigations were not continued. It should be mentioned that in examinations of appendices removed at operation it is not uncommon, in cases looked upon as chronic disease, to find congestion of the mucous membrane under faecal accumulations.

Stercoliths are not infrequently torpedo-shaped. This suggests some moulding by the contractions of the enclosing musculature and supports the view that they are progressively formed over a period of time. There is no evidence at all that they pass from the caecum. That the stercolith may not be firmly fixed is shown by two cases where at operation it was pushed back into the distended part and the obstruction and distension relieved: also by a

case where, in manipulations to bring an obstructive appendix to the surface, a stercolith near the caecum slipped out and the obstruction was relieved.

Hurst states that chronic constipation may lead to catarrhal colitis which he attributes to "mechanical and chemical irritation of scybalous masses". Only occasionally is there blood passed, due probably to small superficial erosions. Such changes are practically limited to the sigmoid and rectal regions. Trauma here, not infectivity, is the main factor and this is the view which should be taken of the way the stercolith and scybalous mass act. The true stercolith, which may be looked upon as a more intensely dehydrated and compressed scybalum, is unlikely to be as infective as moist soft faeces. There is no evidence that, in the absence of acute obstruction, the presence of mere faecal accumulations in the large bowel leads to the occurrence of inflammatory lesions.

Sadyoun and Oppenheimer (1939), in a combined roentgenological and pathological investigation, have given a scientific background to Shattock's hypothesis (1916) of a neuromuscular inco-ordination, secondary to disease, as the cause of faecal stagnation in the appendix. That the musculature is not at fault can be demonstrated by contractility after removal. Many examples could be given of this. To cite one: a woman of 22 had symptoms and signs pointing to chronic appendical disease. At operation the appendix was a pink-grey colour with small vessels ramifying externally. It was full throughout of semi-solid soft faecal material just like a miniature motion. The mucous membrane appeared practically normal. The appendix was cut longitudinally from end to end and the faecal contents washed out. The appendix then contracted down from a measurement of  $3\frac{1}{2}$  in. to  $2\frac{1}{2}$  in. in length. This problem of stagnation is of significance when the stercolith is considered, for it is itself stagnation of faeces and that over probably a considerable period of time. It is therefore present in an appendix already diseased.

The presence of faeces in appendices removed for chronic disease (64 per cent) and the absence in acute disease (empty 48 per cent, stercolith present 32 per cent, faeces only 20 per cent) has been dealt with (Bowen, 1943). The point is that in chronic disease there is 'stagnation, and further, in some cases there is no sign of any active disease. The relatively high percentage of cases in which the lumen is empty in acute disease has also been discussed and cannot be considered further here, save to say that it has not the positive value given to the chronic case, for there is reason to believe that the lumen is emptied, save for the stercolith, in the majority of cases at the onset of the acute attack. Since there is often history and signs of old disease in many cases it suggests some supreme effort to clear the lumen in the presence of acute infection.

If one may speculate on this phenomenon it is to suggest that the neuromuscular fault is relative, and in the presence of a potential aggravating factor, in this case an acute catarrhal infection, some excessive call is made.

If the presence of faecal material in the lumen plays an important part in the onset of obstructive appendicitis we are justified in the conclusion that in the presence of a stercolith there would be faecal matter held up distal to it, since it is almost unknown for the disease to start proximally to the stercolith. From the records of the 21 cases of obstruction associated with a stercolith only 10 give information on this point. In 7 there was no faecal content, in 3 it was present. The result of this analysis can only be said to be suggestive. The figures in relation to the retention of faeces in cases of spasm are even smaller, for of the 5 cases clear fluid was present in 1 only and faecal matter present in 4. If we accept these latter figures and further investigation should substantiate the proportionate numbers, we should explain them, on the hypothesis of spasm, as the persistence of the inco-ordination of muscle action which failed to evacuate the faeces and took on a vicarious activity. In dwelling on this hypothetical spasm one must recognize that its manifestation must vary in degree and extent of muscle involved according to the like proportionate damage to the controlling plexus of nerves.

Finally it may be pointed out that in the normal appendix faecal stagnation does not occur. Temporary retention is physiological and cannot produce a pathological sequence. We must conclude that it is not the presence of faeces which sets up the primary appendicular inflammation.

Neither is there any clear evidence that when infection of the appendix has led to stagnation but not stercolith formation the presence of faecal accumulations in the lumen intensifies the disease. Even in the acute catarrhal case, despite an empty lumen, the disease runs a definite course with intense congestion and often lymph on the peritoneal surface, yet it is unusual for it to result in the grosser and more dangerous phases of perforation and gangrene. It usually settles down again if left alone, but leaves changes which even macroscopically are often visible. Aschoff's opinion (1931) was that unless the acute attack subsided within 24 hours of onset permanent injury was done. It is not uncommon to have a history of a previous attack of more than 24 hours' duration. An analysis of 117 cases of acute appendicitis, some with and others without faecal stagnation, may be of interest. (If one accepts the view of the clearing of the appendix by primary colic, which has some basis even though it cannot be looked upon as other than a hypothesis, then a rapid recovery might be expected to result after the clearance.)

Analysis of 117 cases of acute inflammation gives the following:—

1. Faecal material present in the lumen :
  - a. Gangrene of the appendical wall, 12 (2 of these had gangrene of mucous membrane only).
  - b. Without gangrene, 18 (3 of these were filled throughout with faeces).
2. No faecal material present :
  - a. With gangrene, 20.
  - b. Without gangrene, 67.

Considering these figures, the following comments may be made: (1) Where stagnation is present the ratio of gangrene to non-gangrene is fairly close (2 to 3). (2) There were 3 cases where the appendix was stuffed full of faeces from end to end yet no gangrene resulted. (3) In the cases where the lumen of the appendix was empty the proportion of gangrene to non-gangrene is 2 to 7. Whilst this may appear to support the dangers of faecal stagnation, it may also be used as evidence that in group 1 with faecal stagnation more serious damage has been done since the musculature is unable to get rid of this faecal material at the beginning of the attack. Taken as a whole, and remembering the stagnation in the chronic cases, that in the group 1 the milder form of the disease predominates and there may be no grave effects even with a full appendix, and that in class 2 a fair proportion of the cases are associated with gangrene, it may be said that there is not sufficient evidence that the presence of faeces accentuates the severity of the disease and that on the whole the balance is against such an opinion. It does not follow that such stagnant faeces do not keep up a low-grade inflammation which, as already mentioned, may often be found in chronic disease.

We have to remember here that both abscess formation and peritonitis can result, though not commonly, without perforation or gangrene; that local protective factors, difficult to assess, must play a part. Lymphatic spread probably accounts for this and Seng's description of the extensive lymphatic system suffices to explain the means to the end. A primary virulent attack may result in rapid extension to the peritoneal coat before cedema, thrombosis, and gross nutritional disturbances have come into action.

There remains for consideration the problem of why in one case a stercolith leads to local perforation and in another to obstruction. It would be reasonable to attribute the perforation to the hard and unyielding character of the stercolith, which by pressure on the congested and swollen mucous membrane, possibly accentuated by spasm in the neighbourhood, rapidly leads to a destructive local lesion, whereas the softer type of faecal lump, or even scybalous mass, would act merely as an obstructive agent. This view is, however, untenable, for stony hard stercoliths are found with the obstructive type of the disease and relatively soft ones with the perforative. The hypothesis which seems to fit the picture best suggests that in the perforative type the primary appendicular infection starts

in the near region of the stercolith and in the obstructive well beyond it.

Most authorities hold the view that the disease begins, almost invariably, in the distal part of the appendix as a simple catarrhal inflammation. A personal impression, but without figures to support it, is that the most typical cases of obstructive appendicitis are those where the obstruction is close to the caecal opening. If this is correct it lends support to the hypothesis.

Diagnostically there is no distinctive clinical picture of obstructive appendicitis. We might expect the outstanding symptoms to be pain, the early para-umbilical type; yet it is not so. In a pronounced case the colic may be neither severe nor persistent. As the disease is primarily an infective process, the element of fever may be present from the first or gradually develop as in other forms. There is nothing characteristic about it. The same may be said of the vomiting. Any case of acute appendicitis may be obstructive in character. It is generally agreed that in the classical type of the disease the sequence of pathological changes is destructive, and this being so no case of acute appendicitis should be watched for more sinister signs and symptoms to develop to square with some preconceived notion. It is not uncommon to hear it said that as the speaker suspected obstructive appendicitis, the decision had been made that operation should not be delayed. The inference is obvious.

There is no need to dwell in any detail on the treatment of obstructive appendicitis. Since diagnosis is uncertain as between the obstructive and other forms of appendicitis, any case of acute appendicitis should be operated upon as soon after diagnosis as possible. Over 50 per cent of all acute cases will, if left, lead ultimately to gross infection of the abdominal cavity. This infection will usually be local, for it is a mistake to think that in the obstructive type local adhesions do not form. Exceptionally the disease may progress too rapidly for localization. Perforation in the

area of the stercolith may occur earlier and is probably the more dangerous. In many cases when exposed the sausage-like appendix is greenish and mottled. At this stage it is not gangrenous, although its appearance is very disturbing to younger surgeons who are justified in associating the coloration with necrosis. In such cases it is common to find only clear fluid in the neighbourhood and there is no smell. If after removal the appendix is opened and washed it will often be seen to be a vivid scarlet red in colour after the brown-black fluid contents have been washed away.

### SUMMARY

The incidence and causes of obstructive appendicitis are given. The stercolith and 'spasm' are shown to be the two common causes and both are discussed. Faecal stagnation as the primary cause is investigated and abandoned. A hypothetical reason for the onset of obstruction instead of perforation when a stercolith is present, is brought forward. Diagnosis and treatment are briefly considered.

I am indebted to my colleague, Mr. V. C. Pennell, for kindly reading through the paper and making helpful suggestions.

### REFERENCES

- ASCHOFF (1931), *Munch. med. Wschr.*, **178**, 1419.  
 BEHAN (1921), *Amer. J. med. Sci.*, **162**, 705.  
 BOWEN, W. H. (1935), *Appendicitis: A Clinical Study*.  
 Cambridge Univ. Press.  
 — (1943), *Brit. J. Surg.*, **31**, 127.  
 HURST (1909), *Constipation and Allied Intestinal Disorders*. London.  
 SADIYOUN and OPPENHEIMER (1939), *Amer. J. Roentgenol.*, **41**, 188.  
 SENG (1920). See Aschoff's *Der Appendicitis Anfall*.  
 Berlin.  
 SHATTOCK (1916), *Proc. R. Soc. Med.*, **13** (Pathol. Sect.), 128.  
 WILKIE, D. P. D. (1914), *Brit. med. J.*, **1**, 959.

## PLASMOCYTOMA OF BONE

By WILLIAM TENNENT

RADIOLOGIST, SELLY OAK HOSPITAL, BIRMINGHAM

THE plasmocytomata are somewhat rare tumours composed of true plasma cells or their immediate precursors. They arise chiefly in two entirely different sites—namely, the lymphatic tissue of the nasopharynx and the bone-marrow.

Nasopharyngeal plasmocytomata present a picture of nasal obstruction, dysphagia, and haemorrhage, occurring usually in males over 40 years of age. They are generally mistaken for the more malignant lymphosarcoma and their true nature is only revealed by the histologist or by the unexpected survival of the patient after

several local operations; for they almost invariably show local recurrence, although general dissemination is uncommon. Like the type occurring in bone, they may, after an interval of months or years, develop a condition indistinguishable from multiple myelomatosis (Jackson et al., 1931). These nasopharyngeal tumours have been admirably reviewed by Blacklock and Macartney (1932) and will not be further referred to herein.

Plasmocytoma of bone arises in the marrow of flat bones, long bones, or vertebrae; it does

not appear to have been recorded in the small bones of the hands or feet. Its favourite sites appear to be the ilium and proximal ends of femur and humerus. As an isolated tumour of bone it has been described under such names as 'benign lymphosarcoma', 'reticulosarcoma', 'plasmoma', and more frequently as 'solitary myeloma' (Pasternack and Waugh, 1939). Most of these terms appear to be unsuitable; its clinical course is quite different from that of a lymphosarcoma, its claim to rank as a variety of reticulosarcoma is probably sound, but must remain *sub judice* until the origin of the plasma cell is finally settled, while the term 'solitary myeloma' inevitably brings to mind the quite unrelated giant-cell osteoclastoma which was formerly included in the 'myelomata'. On the whole, the name plasmocytoma—which is the one adopted in the more recent publications—seems the most satisfactory. It is in accord with the histological findings and serves to distinguish this tumour as a distinct clinical entity from closely related conditions such as multiple myelomatosis.

That it forms a distinct clinical entity with a characteristic symptomatology and clinical course can no longer be doubted. The picture is that of a middle-aged male who complains of a constant dull aching pain, usually in the region of hip or shoulder, with local swelling and without limitation of movement. X-ray examination reveals an isolated bone tumour of central origin, which may be tentatively diagnosed as osteoclastoma, endosteal sarcoma, or secondary carcinoma. Biopsy reveals the characteristic cell type, and surgical removal and/or radiotherapy is followed by permanent cure (Vichel and Kirketerp, 1938; Chesterman, 1936), local recurrence (Cutler et al., 1936; Pasternack and Waugh, 1939), or the late onset of multiple myelomatosis (Jackson et al., 1931; King, 1940; Toth and Wintermantel, 1943).

Cases conforming to the above picture and with satisfactory histological verification are occasionally reported in the literature. Chesterman (1936) was only able to find 12 cases, but he restricted his search to those cases where the tumour occurred in a long bone. Pasternack and Waugh (1939) collected 30 cases, but appear to have omitted several cases in the English literature (Leedham-Green et al., 1938) which are undoubtedly entitled to rank as true plasmocytoma of bone. The present writer has been able to trace 49 cases to date, which all exhibited the characteristic clinical picture and are accompanied by histological confirmation. The case reported below appears, therefore, to be the fiftieth, and is of interest as it exhibits the natural course of the disease when uninfluenced by any form of active treatment.

### CASE REPORT

**HISTORY.**—The patient, a male aged 50 years, a ticket inspector, was admitted to hospital on Aug. 30,

1938, with the provisional diagnosis of pneumonia. Five days prior to admission the patient had, while at work, a sudden severe rigor, which was shortly followed by a pain in the left side of the chest, prostration, and difficulty in breathing. Next day, as he felt no better, his private practitioner was called in and the patient was told he had pneumonia. Sulphonamides were exhibited in small doses (one 0.5-g. tablet four times per day), and as he had shown little improvement in five days, he was admitted to hospital as a case of pneumonia not responding to treatment.

**Past history:** Chicken-pox and measles in childhood. Two attacks of "influenza", the last six years previously. Three years prior to admission he had "rheumatic" pains in right hip following a fall and was told he had "arthritis". He had slipped and fallen while hurrying to work one morning, but got up and continued on his way. About three weeks after this fall he consulted his doctor for what he thought was rheumatism in the right hip, and he vaguely connected this with his accident. These pains in the right hip had continued off and on for three years, but had never been sufficiently severe to keep him off work.

**ON EXAMINATION.**—On admission, temperature 102° F., pulse 95 per minute, respirations 36 per minute. His face was flushed, he looked toxic, and a crop of herpes was present on the upper lip. Signs of consolidation were present at the left base, and he was thought to be suffering from a typical lobar pneumonia involving the left lower lobe.

Examination of the abdomen, however, revealed a mass deep in the right iliac fossa, slightly tender to pressure and apparently fixed to the posterior abdominal wall and free anteriorly. The first possibility thought of was a perinephric abscess. Urine was free from albumin, but contained an occasional

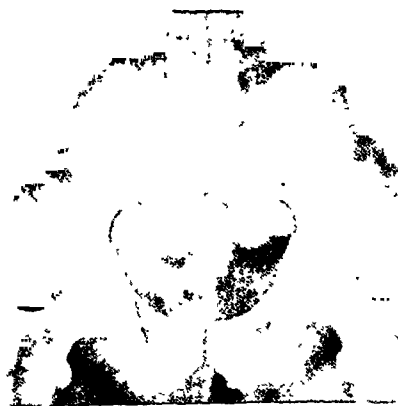


FIG. 406.—Plasmocytoma of right ilium. Radiograph showing gross destruction of the blade of the ilium, with marginal expansion and coarse trabeculation.

hyaline cast and a few red blood-corpuscles. Physical examination was otherwise negative.

**SUBSEQUENT COURSE.**—The chest condition rapidly responded to full doses of sulphonamides, and within a week the temperature fell to normal and X-ray examination of the lungs showed only residual hyperæmic changes in the left lower lobe. The mass in the right iliac fossa, however, remained unchanged and intravenous pyelography was carried out with a view to determining whether or not it was related to the right kidney. The pyelogram was within the limits

of the normal, but the right ilium was seen to be partially destroyed. Additional views of the bony pelvis reveal the appearances seen in Fig. 406. This

cavity. The solitary exception occurred in the left femur, where there was a localized area of cortical erosion. No glandular enlargement was detectable,

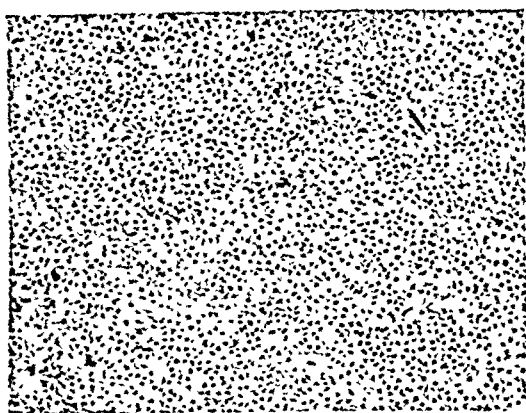


FIG. 407.—Low-power view, showing highly cellular nature of lesion with poor fibrous stroma. ( $\times 60$ .)

shows almost complete destruction of the central portion of the blade of the right ilium, with expansion of the cortical bone and coarse irregular trabeculation within. The cortex, however, while expanded, is not destroyed, and the tumour is not invading the surrounding soft tissues. A tentative radiological diagnosis of giant-celled osteoclastoma was made, but a note was added to the effect that the radiological appearances were not absolutely typical and biopsy was advised. This was immediately carried out, and the microscopical appearances of the tissue removed are seen in Figs. 407, 408, which show a highly cellular tissue, with cells approximating to the plasma type.

As the histological appearances resembled those seen in multiple myelomatosis, a radiological search of the skeleton was made for additional foci, but apart from the right ilium no bone lesion was found. He was advised to undergo a course of deep X-ray therapy, but declined the offer, and left hospital as soon as he had recovered from the pulmonary lesion. Nothing further was heard of him for a period of over two years.

**RE-ADMISSION.**—On Oct. 2, 1940, the patient was re-admitted to hospital. For three months prior to his re-admission he had suffered from general weakness, loss of weight, and shortness of breath, sufficient to keep him off work. In addition, he stated that he had a constant ache in the right side where the primary lesion was and that pain in both thighs and arms was occasionally severe.

On examination he appeared very ill, and had obviously lost weight. There was only a slight increase in the size of the mass in the right ilium and X-ray examination revealed that the tumour was still contained within the expanded cortex. Radiography of the skeleton, however, revealed a state of affairs indistinguishable from multiple myelomatosis. The left femur (Fig. 409) showed multiple circular areas of rarefaction and a few similar 'punched-out' areas were present in the cranial vault, ribs, and both humeri. These areas showed the characteristic appearances of multiple myelomatosis, each having a smooth and sharp circular or slightly oval margin exactly comparable to a series of 'drill holes' driven through the bone. With one exception they were entirely confined to the marrow

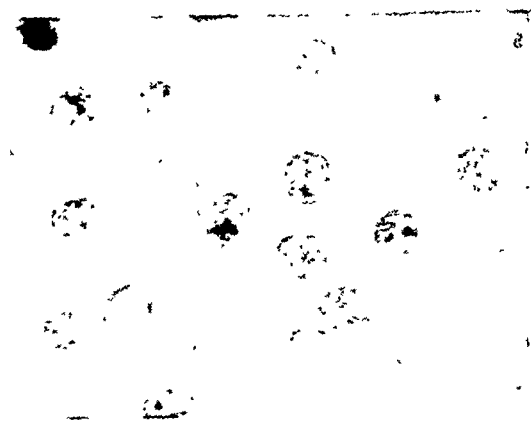


FIG. 408.—High-power view to show the nuclear structure. ( $\times 800$ .)

and a diligent search failed to reveal any additional primary focus of malignant disease.

**Urine:** Bence-Jones proteose present. A few hyaline casts, red cells, and leucocytes were noted, and culture gave a growth of *Staph. albus*.



FIG. 409.—Left femur with several sharply circumscribed foci of multiple myelomatosis (other bones exhibited similar changes).

**Blood:** Wasserman reaction negative. Sedimentation-rate, 65 per cent. Serum-calcium, 11.6 mg./100 c.c.; Plasma-phosphorus, 5.8 mg./100 c.c.; Uric acid, 6.3 mg./100 c.c.; Urea, 37 mg./100 c.c.; Plasma-albumin, 2.5 per cent; Plasma-globulin, 7.2 per cent; A/G ratio, 0.3. Hæmoglobin, 60 per



cent. Red cells 3,300,000; White cells 16,000 (polymorphs. 68 per cent, lymphocytes 22 per cent, monocytes 6 per cent, myelocytes 4 per cent, occasional myeloblasts noted).

The general condition deteriorated rapidly and the patient died at home a few weeks later.

**Comment.**—The patient had thus, without any treatment which could have influenced the course of the disease, survived for a period of over five years from the first onset of symptoms referable to the right ilium; but once generalization had occurred he survived for slightly less than five months. The growth in the right ilium apparently advanced slowly and remained localized for four and a half years. It is, therefore, not unreasonable to assume that if it could have been subjected to radical surgical clearance or adequate radiotherapy, the fatal onset of multiple myelomatosis might have been prevented. It also raises the question as to whether, as is generally assumed, multiple myelomatosis is a system disease of the bone-marrow, with independent multicentric origins, or (as suggested by King, 1940) whether it merely represents the terminal stage of multiple metastases from a primary plasmacytoma.

## DIFFERENTIAL DIAGNOSIS

**Radiological Diagnosis.**—The X-ray appearances vary according to the site of the primary tumour, but all have certain features in common. Illustrations of plasmacytoma of the ilium almost identical with *Fig. 406* have been published by Leedham-Green et al. (1938); indeed; it is only by contrasting the differences in trabeculation and the presence of phleboliths that the two can be told apart (as both patients lived in the same area the author has been at some pains to verify that they were, in fact, two different patients and not related in any way). Several American writers (Cutler et al., 1936; Geschickter and Copeland, 1936; Liebman and Goldman, 1936; Toth and Wintermantel, 1943) also publish closely similar cases of the disease originating in the ilium. All these have the following features in common: The blade of the ilium is irregularly expanded, chiefly in its vertical plane. The cortex is thinned but not usually broken, while coarse trabeculae cross the medullary cavity generally in a vertical direction. There is no sclerosis or new-bone formation and the growth is completely osteolytic in nature. In all of the above cases the first radiological diagnosis was that of a giant-cell osteoclastoma, as the ilial changes closely resemble those seen in osteoclastoma occurring at the ends of long bones. Nevertheless, osteoclastoma in a flat bone is extremely rare, and if such appearances occur in a flat bone the probability is in favour of plasmacytoma.

Osteochondromata not infrequently occur in relation to the ilium, but the radiological picture of large translucent areas of cartilage containing

multiple small punctate spots of calcification is quite distinctive.

When plasmacytoma occurs in a long bone the radiological appearances may again simulate osteoclastoma, but here again the site is distinctive, the plasmacytoma seldom occurring at the extreme end of the bone, and the true osteoclastoma seldom occurring in the shaft. Extension is chiefly in the long axis rather than in the transverse axis, and there is complete absence of periosteal or osteogenic reaction. In those cases where trabeculation is absent the diagnosis is chiefly from simple bone cyst, Ewing's tumour, endosteal sarcoma, osteitis fibrosa cystica, and secondary carcinoma. The age of the patient is some help, as simple cysts, Ewing's tumour, and endosteal sarcoma are chiefly seen under 20 years, while nearly all cases of plasmacytoma are over 40. Bone sarcomas, on the whole, tend to erode and break through rather than to expand the cortex and are commonly associated with periosteal and osteogenic reactions. Osteitis fibrosa cystica has generally multiple bone lesions, all of which present similar radiological appearances, while the whole skeleton shows a generalized osteoporosis often with bending of the bones from weight-bearing. A secondary carcinomatous deposit in a long bone is probably the most difficult of all to distinguish from a plasmacytoma, and when the primary carcinoma is small and not discoverable the distinction on radiological grounds may be impossible. Some assistance may be derived from the multiple nature of the secondary deposits and the uniformity of their appearance.

It is worth noting that if a case of plasmacytoma does subsequently develop a multiple myelomatosis, the multiple bone lesions bear no resemblance to the primary plasmacytoma, but appear as small circular sharply-defined areas of rarefaction within the medullary cavity. Pathological fracture occurs with high frequency in all of the conditions named and is not a distinguishing feature of any.

**Blood Examination.**—The diagnostic value of sternal puncture has recently been suggested by several writers (Bichel and Kirketerp, 1938; Hadfield and Garrod, 1942; Stewart and Parkes-Weber, 1938), and it is stated that even with an apparently strictly localized tumour true plasma cells, or cells identical with the tumour cells, may be found in excess in the sternal marrow. Bichel and Kirketerp report 2 cases of apparently solitary tumours where such sternal marrow changes were found, though the rest of the skeleton was radiologically negative for growths. Sternal puncture appears to be the only examination of value while the growth retains its character as a localized plasmacytoma, the blood chemistry being, as a rule, normal at this stage and the Bence-Jones test negative.

With the onset of multiple myelomatosis, however, the characteristic changes in the blood such as are found in the present case appear.

The serum-calcium may arise, and, if there is renal damage, phosphorus retention will occur. This is of some assistance in distinguishing the condition from osteitis fibrosa cystica due to parathyroid tumour, as in the latter case the rise of serum-calcium is generally associated with a fall in the plasma-phosphorus (Snapper, 1943). The high blood-uric-acid which is sometimes present is attributed by Stewart and Parkes-Weber (1938) to the breakdown of nucleoproteins derived from the tumour cells. Like Bence-Jones proteosuria, raised blood-uric-acid is an inconstant finding, being present in about the same proportion of cases (60 per cent). Inversion of the albumin-globulin ratio is more commonly present and the normal ratio of 2:3 may be altered to 0.3, as in the case herein reported. The cellular elements may exhibit a hypochromic anaemia or, more rarely, a leuco-erythroblastic reaction, with the presence in the circulating blood of a few cells identical with those found in the primary tumour.

**Histological Diagnosis.**—Despite the information to be derived from radiology and blood examination, biopsy must be resorted to if an absolute diagnosis is to be established. Nevertheless, even when sections have been prepared, the true diagnosis may not be immediately apparent. Toth and Wintermantel (1943) circulated their material and state that "The reports of several pathologists were contradictory and confusing. Ewing's tumour and myeloma were considered. The preferred diagnosis was 'myeloma'." In Chesterman's case (1936) the original histological diagnosis was 'large round-cell sarcoma', on the strength of which the limb was amputated. Only on subsequent examination was the diagnosis modified to plasmocytoma.

The sections in the present case showed a highly cellular tissue with little fibrous stroma, a few areas of hæmorrhage, and many thin-walled capillaries; these latter often being closely surrounded by tumour cells. The cells were of large size, averaging 10–12  $\mu$  in diameter and had the appearance of atypical plasma-like cells. Their prominent nuclei were mostly round, generally central, but sometimes eccentrically placed in a large amount of poorly staining cytoplasm. Occasional cells, especially those with eccentric nuclei, showed a perinuclear halo, while in other places the cell membranes were difficult to distinguish and the nuclei had the appearance of being set in a syncytium. The nuclei themselves were packed with more deeply staining particles which frequently showed a 'clock-face' arrangement. Mitoses were seldom observed.

Some of the histological difficulties undoubtedly arise from the fact that this tumour may occur in a variety of closely related types. Stewart and Taylor (1932) divide them into plasmocytomas and plasmosarcomas, and other writers (Ewing, 1940; Geschickter and Copeland,

1936; Kaufmann, 1929; Sugarbaker and Carver, 1940) agree that there is a slowly growing type composed of true mature plasma-cells, and a more rapidly growing anaplastic type resembling a reticulosarcoma or lymphosarcoma. The cells of this anaplastic type tend to have nuclei which are slightly larger than the nuclei of the fully developed plasma-cells, and also to have their nuclei more centrally placed in the cytoplasm. These anaplastic cells may fail to take the typical plasma-cell stain by the Unna-Pappenheim method, and the perinuclear halo, so typical of the mature plasma-cell, may be poorly developed or entirely lacking. This is the type which shows the greatest tendency sooner or later to develop a frank multiple myelomatosis.

## DISCUSSION

On analysis of the 50 recorded cases it is found that 35 (70 per cent) were men and 15 (30 per cent) were women. The average age at the time the diagnosis was established was 51 years. Regarding the site, the distribution was as follows: Pelvis 16, femur 12, humerus 9, vertebrae 6, skull 5, tibia 1, clavicle 1. Presenting symptoms were either pain, pathological fracture, or local swelling. When the tumour occurred in a long bone the tendency to pathological fracture was strikingly high. In the lower limb all of the cases showed a fracture either as the presenting symptom or after biopsy or curettage, while of the humeral cases only one escaped fracture. Of the vertebral cases three showed some degree of collapse.

An unfortunate feature of the reported cases is a lack of adequate follow-up. Of these 50 cases 28 (56 per cent) had been followed for less than 2 years before publication, which makes it quite impossible to quote anything in the nature of survival rates. Nevertheless, out of the total, 15 (30 per cent) developed multiple myelomatosis at periods varying from two months to six years from the time of the original diagnosis.

Regarding the origin and nature of these tumours there is much difference of opinion. Ewing (1940) "assumes" that the plasma cells are derived from the adventitial cells of the blood-vessels of the marrow, while others are of the opinion that they are derived from the reticulum cells (Ribbert, 1889). Parsons (1943), working on animals, has brought forward evidence to show that the fixed reticulum cells are the direct precursors of the plasma cells, and that these fixed reticulum cells are identical with Maximow's undifferentiated mesenchyme cells. Robb Smith (1938) has classified the reticulosos and reticulosarcomata on an exact cytological basis and his classification has met with general acceptance. He includes plasmocytoma in that subgroup of reticulosarcoma where the reticulum cells show differentiation to the hæmic type of cells and to the plasma cell in particular. Versiani et al. (1944), in describing an eosinophilic tumour of the marrow, come to similar conclusions

regarding the possibilities of the cell origin, while Christian (1907) believes that all cells seen in plasmocytoma and multiple myeloma are transitional in type and not to be classed as either true plasma cells or true cells of the myelocytic series. The weight of evidence, therefore, appears to be in favour of the tumour arising as a variant of the reticulum cell in the course of its differentiation into cells of the hamie type. For simplicity of description the plasmocytoma has been spoken of throughout this report as a 'tumour', but informed opinion is divided as to whether the condition is entitled to rank as a neoplasm or as a granuloma. British authorities (Stewart and Taylor) tend to regard it as a true neoplasm, while on the Continent (Kaufmann, 1929) there is a tendency to include it in the granulomata. No final verdict on this point appears at the moment to be possible. It is well, however, to recall that the high incidence of subsequent multiple myelomatosis, and the observation (Bichel and Kirketerp, 1938; Hadfield and Garrod, 1942) that even in the solitary state changes may be found in the sternal marrow, renders it, if a neoplasm, one of a most unusual type.

Treatment in the reported cases consisted of either amputation, curettage, deep X rays, or radium. Nothing is to be learned as to the relative merits of these methods from a study of the cases, owing to the lack of adequate follow-up. Several of the writers, indeed, appear to be unaware of the danger of multiple myelomatosis, and take an unduly optimistic view of the prognosis, while others (King, 1940) believe "that it is only a matter of time before a solitary myeloma of bone becomes a multiple lesion with a fatal termination". In general, it may be said that the prognosis is less favourable than in osteoclastoma and considerably more favourable than in osteogenic sarcoma, with the possibility of an untreated case (as herein described) surviving for a period in excess of five years. The danger of attributing curative powers to any particular therapeutic medium is well illustrated by the present case. Had he received deep therapy or had the bone been curetted when he first consulted his doctor, his survival would doubtless have been attributed to this; yet he can legitimately be classed as a 'five-year survival' in the absence of any treatment whatever.

### SUMMARY

1. Evidence is submitted to the effect that plasmocytoma of bone forms a distinct clinical picture of a solitary intramedullary neoplasm, remaining strictly localized for several years, but if untreated developing into the fatal condition of multiple myelomatosis.

2. A case conforming to this description is reported, where the primary plasmocytoma

remained localized in the right ilium for 4½ years, with subsequent development of multiple myelomatosis, and death 5 years after first symptom. This case illustrates the natural history of the disease in the absence of treatment.

3. The available cases in the literature are briefly reviewed, the differential diagnosis discussed, and a note added on the probable origin and nature of the disease.

It is a pleasure to acknowledge my indebtedness to Dr. William Whitelaw and Dr. Charles Ware, not only for laboratory facilities, but for much helpful discussion concerning the pathogenesis of this condition.

### REFERENCES

- BICHEL, J., and KIRKETERP, P. (1938), *Acta. radiol. Stockh.*, **19**, 487.  
 BLACKLOCK, J. W. S., and MACARTNEY, C. (1932), *J. Path. Bact.*, **35**, 69.  
 CALLENDER, G. R. (1934), *Amer. J. Path.*, **10**, 443.  
 CHESTERMAN, J. T. (1936), *Brit. J. Surg.*, **23**, 727.  
 CHRISTIAN, J. (1907), *J. exper. Med.*, **9**, 325.  
 CUTLER, M., BUSCHKE, F., and CANTREL, S. T. (1936), *Surg. Gynec. Obstet.*, **62**, 918.  
 EWING, J. (1940), *Neoplastic Diseases*. Philadelphia and London.  
 GESCHICKTER, C. F. (1930), *Ann. Surg.*, **91**, 425.  
 — and COPELAND, M. M. (1936), *Tumours of Bone*, New York.  
 HADFIELD, G., and GARROD, L. P. (1942), *Recent Advances in Pathology*, 49. London.  
 JACKSON, H., PARKER, F., and BETHEA, J. M. (1931), *Amer. J. med. Sci.*, **181**, 169.  
 KAUFMANN, E. (1929), *Pathology*, **2**, 1221. London.  
 KING, B. B. (1940), *J. Amer. med. Ass.*, **115**, 36.  
 LEEDHAM-GREEN, J. C., BROMLEY, J. F., and RABAN, J. (1938), *Brit. J. Surg.*, **26**, 90.  
 LIEBMAN, C., and GOLDMAN, S. E. (1936), *Canad. med. Ass. J.*, **34**, 511.  
 MUIR, R. (1941), *Text-book of Pathology*, 253. London.  
 PARSONS, DOROTHY L. (1943), *J. Path. Bact.*, **55**, 397.  
 PASTERNAK, J. G., and WAUGH, R. L. (1939), *Ann. Surg.*, **110**, 427.  
 PAUL, L. W., and POHLE, E. A. (1940), *Radiology*, **35**, 651.  
 RIBBERT, H. (1889), *Beitr. path. Anat.*, **6**, 185.  
 ROBB-SMITH, A. H. T. (1938), *J. Path. Bact.*, **47**, 457.  
 STEWART, A., and PARKES-WEBER, F. (1938), *Quart. J. Med.*, **7**, 211.  
 STEWART, M. J., and TAYLOR, A. L. (1932), *J. Path. Bact.*, **35**, 541.  
 SHAW, A. F. B. (1923), *Ibid.*, **26**, 125.  
 SNAPPER, I. (1943), *Medical Clinics on Bone Diseases*. New York.  
 SUGARBAKER, E. D., and CARVER, L. F. (1940), *J. Amer. med. Ass.*, **115**, 17.  
 TOTH, B. J., and WINTERMANTEL, J. A. (1943), *Radiology*, **41**, 472.  
 VERSIANI, O., FIGUEIRO, J. M., and JUNQUEIRA, M. A. (1944), *Amer. J. med. Sci.*, **207**, 161.  
 WATSON-JONES, R. (1941), *Fractures and Other Bone and Joint Injuries*, 2nd ed., 179. Edinburgh.  
 ZDANSKY, E. (1927), *Fortschr. Röntgenstr.*, **36**, 368.

# OPERATIVE REPLACEMENT OF THE MAMMARY PROMINENCE

BY SIR HAROLD GILLIES, C.B.E.

THE desirability of an easy direct method of forming a mammary prominence after mastectomy will be readily admitted. The patient is usually very self-conscious of her asymmetry, and although the artificial shield gives her confidence when dressed, the thought that it is a removable ornament leaves her with a lasting complex affecting her whole outlook. That a large percentage of these cases recur is not a valid argument in favour of denying the patient such happiness as may remain to her. The commonly expressed thought of many surgeons that any interference in the area of the excision is liable to stir up a recurrence does not invite conviction. On the contrary, it is more than probable that the tension produced in some resutures after excision is a potent cause of local irritation, and a possible agent of recurrence. Even more so is this the case when a raw area has to be left to granulate. Plastic surgery has so definitely shown the value of suture without tension in all flesh wounds, and grafting with split skin is such an established process, that these two common faults in technique are no longer justified.

The justification of publishing this method on one case may be sought in the numbers of such cases to which it can be applied and in the apparent simplicity and reliability of the method.

and one sub-stage are required. The first makes the pedicle—preferably four weeks after the breast operation—the sub-stage two weeks later increases the pedicle to include the 'new breast'. At the end of four weeks, perhaps at the time of the mammary excision, the 'breast' is slung up to take its proper position. It remains to divide and replace or discard part of the pedicle not wanted. This third stage may be deferred for a considerable period if desired, but should not be performed less than three weeks from the previous stage.

**First Stage.**—A curved tubed-pedicle flap is designed on the affected side with its centre situated in the midaxillary line about the level of the 6th rib. It should be 3 in. to 4 in. broad, according to the size of the patient, and will contain a considerable length of the thoraco-epigastric vein. The parallel cuts are continued in a curved fashion towards that abdominal prominence which surrounds the umbilicus. The strap pedicle flap, 6 in. long, is lifted from the deep fascia along that easily followed plane between the superficial and deep fascia. This is accomplished mostly by dry swab 'dissection'. Bleeding points are arrested and sought for, particularly on the under side of the flap. These, it should be remembered, are often missed, since

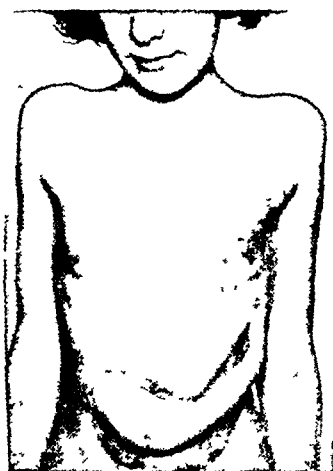


FIG. 410.—Design of curved tubed-pedicle flap.

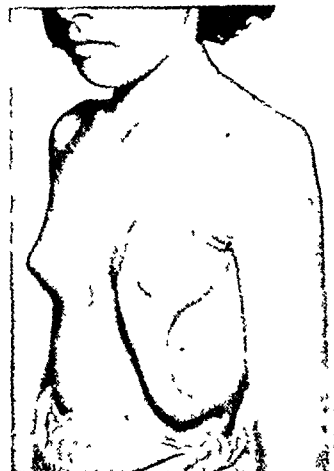


FIG. 411.—Suture of pedicle into recipient area.

References to previous publications are given (Gillies, 1920; Webster, 1937).

## TECHNIQUE

The method consists of transferring the circum-umbilical skin and fat pad by means of a tube pedicle to form the 'breast.' The umbilicus is turned out to form the 'nipple'. Three stages

the act of turning the flap out to find such bleeders may in itself stop them. Fine 10/0 catgut is adequate for the larger of these small vessels. With the edge of the flap still conveniently held by fine hooks the fat is trimmed from each edge. If this is neglected there may be tension on folding the flap. The suture is accomplished by putting in an interrupted Deknatel suture at each end

and one in the middle approximating the two edges of the flap. See that there is no tension on the end stitches, which usually are placed at about  $1\frac{1}{2}$  in. from the end of the incision. The stitch ends may be held up by an assistant to facilitate the insertion between them of a subcuticular stitch with an eyeless needle and medium

remaining attachment at the abdominal end may be divided and the flap partly opened out and sutured into the place prepared for it (Fig. 411).

If the excision of the mamma has been undertaken at the same time as this stage of the repair, it may well be wise to give the patient a long convalescence before cutting off the pedicle.

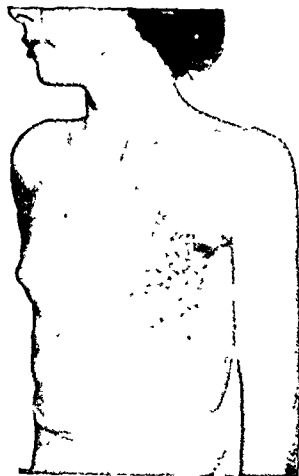


FIG. 412.—Mixed naevus of breast treated by radium.

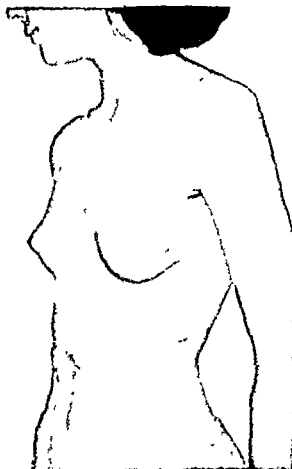


FIG. 413.—Early result of replacement of breast by tubed-pedicle flap.

silk, or of a continuous end-on mattress suture with a 2-in. straight needle and any suture material. Stitches stay in one week.

**Treatment of the Raw or Donor Area.**—Using a Padgett dermatome, or Humby knife, a skin-graft is cut and laid on tulle gras raw surface outwards, and of size corresponding to the raw area. A few long-ended stitches tack this down to the edges, a moderate packing of paraffin flavine wool and wet saline gauze is pressed into a mould over the graft, and the long ends tied over to maintain pressure. Elastoplast is applied under the pedicle across the graft area. The pedicle wound is protected by tulle gras and a layer of gauze. The pedicle should be inspected for hæmatoma the first and second days—otherwise it may be left for the week.

**SUB-STAGE.**—At the end of two weeks the circum-umbilical pad, except for 2 in. on its far side, is incised around its periphery down to fascia and undermined fully. The umbilicus is carefully freed and everted. To fill the hollow made by this eversion two small pads of fat may be left attached to the sides of the umbilicus, which on eversion will come to lie inside the projection, and can be sutured together with light catgut. An alternative method of giving prominence to the nipple is to bury a firm substance such as cartilage, or perhaps one of the new acrylics. The edges of the said flap are sutured together, continuing the tubed pedicle already fashioned, and the raw area similarly grafted. (Fig. 410.)

**Second Stage.**—At the end of a further two weeks, i.e. about four weeks in all, the

**Third Stage.**—This can be done three weeks later, i.e. at seven weeks. It consists in cutting off the excess pedicle from the breast and rounding off the lower outer pole, and of disposal of the pedicle remains. This may be jettisoned if the previous grafting of the donor area is satisfactory, or the longer process of fitting it back whence it came may be undertaken.

### CASE REPORT

The case was referred by Dr. B. H. Gibson through Dr. A. C. Roxburgh. The condition presented was that of a girl of 12 years who had a mixed naevus of the left breast area. She had a normal developing breast on the right side, but no mammary prominence on the left, and only the scarred remains of the nipple. Over the skin of the area was the remains of a warty segmental naevus, a strip of which ran into the axilla. It had been subjected to treatment by radium at the age of seven months, and when reviewed at the age of 10 years evidence of radionecrosis was established. The result had been adequate as regards the removal of the naevus, but radionecrosis had destroyed the surface skin, the breast substance, and, as stated, the nipple, of which there was only a scarred remnant. The area treated was avascular and fibrotic, with some cracking of the epithelium, and showed the remains of the naevus (Fig. 412). The left arm showed some limitation of shoulder movement. Neoplastic change had not yet appeared, but the excision of the area was imperative.

OPERATIVE MEASURES undertaken consisted of:—

1. Raising the pedicle and grafting the raw area, Feb. 25, 1942.
2. Continuing the pedicle, April 9, to convalescence, May 10.
3. Suture of the 'breast' into the area caused by the excision, July 31.

4. Division of the pedicle, Aug. 27.  
Discharged, Sept. 24. Follow-up, Oct. 1, 1943:  
Scars good, except along top border (Fig. 413).  
The anaesthetics were administered by Dr. R. W. P. Shackleton.

At the various stages the assistance of Major Charles Heanley, R.A.M.C., Major Johnson, Norwegian Medical Corps, Major Clarkson, R.A.M.C., and Dr. Castro O'Connor is most

gratefully acknowledged. The photographs were taken by Mr. E. L. Butler at an E.M.S. Unit.

# REFERENCES

- GILLIES, H. D. (1920), *Plastic Surgery of the Face*. London.  
WEBSTER, JEROME P. (1937), *Surg. Clin. N. Amer.*, 145.

## MALIGNANT TUMOURS OF THE SMALL INTESTINE A REVIEW OF THE LITERATURE AND REPORT OF 21 CASES

By KENNETH FRASER, GLASGOW

MALIGNANT tumours of the small intestine are undoubtedly uncommon, though not as rare as is frequently imagined. In 1939 Lewis could find as many as 400 sarcomata of small intestine already reported in the literature, while up to 1941 101 cases had been recorded at the Mayo Clinic alone. Wakeley in 1931 reported that he personally had had 7 cases under his care. Reference is made here to several extensive papers on the subject, including four from the Mayo Clinic, which has by far the biggest series for one clinic.

In this paper 21 new cases are added, 8 of these in detail and accompanied by illustrations to show the types of tumours found and some of the complications which may occur.

### INCIDENCE

In order to provide figures comparable with those of other hospitals, the statistics of the Western Infirmary, Glasgow, were reviewed for the ten years 1933 to 1942. During this decade 13 cases of small-bowel malignancy were found either at operation or autopsy. During the same period there were 22,975 operations on the gastro-intestinal tract (including the biliary system) and the total hospital autopsies numbered 2674.

These 13 accepted cases were all proved histologically or found at autopsy—6 were carcinoma and 7 were sarcoma. Malignancy at the ampulla of Vater was not included because of the difficulty of proving a true intestinal origin for these cases. Further, no case is included in which malignancy elsewhere in the intestines was also present. One case, which at operation seemed like a carcinoma of jejunum, has been excluded since no biopsy was taken and a post-mortem was refused.

The importance of pathological confirmation is shown by the case of a man admitted and operated on as one of acute intestinal obstruction. At operation an annular carcinoma involving the ileum was found and removed. He died on the fourteenth day, and at post-mortem examination the tumour was found to be one of several secondaries from a primary gastric ulcer carcinoma.

To these 13 cases are added 8 others from various sources, 6 carcinoma and 2 sarcoma, giving a total of 21 cases.

Various writers in discussing the incidence of malignant neoplasms in the small intestine have compared their figures with the total number of neoplasms in the alimentary tract from cardia to rectum or in the large intestine alone (Jefferson, 1916; Ewing, 1922; Mayo and Nettrour, 1937; Mayo, 1940). So many factors influence the statistics of a hospital in this matter that the quoted incidences have a very relative value.

**Age and Sex Incidence.**—C. W. Mayo (1940), in 108 cases of malignant disease of the small bowel at the Mayo Clinic, found the average age to be 52.6 years. The age for carcinoma is known to be higher than that for sarcoma, and Ullman and Abeshouse (1932) found that, in 126 cases of sarcoma, the average age was 33. Heggs (1939) refers to a case of carcinoma of the small bowel in a patient aged 3½ years.

This site of malignant neoplasia is estimated by Cameron (1938) and Mayo (1940) to be more than twice as common in males; in this series there were 13 males to 8 females.

### AETIOLOGY

The aetiology of malignant tumours in the small intestine remains as obscure as that of malignant tumours elsewhere in the alimentary tract. Several authors have suggested theories as to why malignancy is so much less frequent here than elsewhere in the intestinal tract, and all seem to be agreed that this is due to the fluid nature of the contents, its alkalinity, and the absence of abrupt bends and stasis so typical of the colon. In discussing carcinoma of the small intestine, Rankin and Mayo mention the possibility of its developing in embryonic rests, or in morbid changes occurring in Brunner's glands, but consider the evidence is so far insufficient. Jefferson (1916) reports a case with a posterior gastro-enterostomy for an apparently simple duodenal ulcer; he did well for a time, but at post-mortem 3½ years later an annular carcinoma was found in the duodenum 1 in.

distal to the pyloric vein and not involving the papilla. He concludes that the malignancy had occurred in the ulcer.

In considering the occurrence of sarcoma, Ullman and Abeshouse (1932), after reviewing 126 cases, find the aetiology of sarcoma even more obscure, and fall back on such explanations as trauma, irritation of chemicals, and antecedent or intercurrent disease; of these the last seems the most probable.

### CLINICAL PICTURE

In many of the cases the onset of symptoms is gradual and may last months and even years as a somewhat vague story of weakness and easy fatigue, with progressive loss of weight, sometimes amounting to 28-30 lb. (According to Rankin and Mayo (1930) the average loss is 28 lb.)

In a large number of cases anaemia is a marked feature, some of which have been diagnosed as cases of pernicious anaemia and treated unsuccessfully as such. W. J. Mayo, in reviewing carcinoma of the colon, pointed to the occurrence of marked anaemia in carcinoma of the proximal colon. The anaemia in this condition is very similar to that described by Mayo for the proximal colon and that found in cancer of the stomach. Mitchell Heggs (1937) quotes Plunket and Foley, who are of the view that the macrocytic character is due to failure of absorption of the haemopoietic substance of Castle through the diseased wall, and the microcytic from failure of absorption of iron in the general state of malnutrition; on the other hand, though less likely in view of the type of anaemia, it may be accounted for in the blood-loss from the ulcerated areas found in many of the tumours. It is difficult to believe that a growth with a surface area so minute in comparison with the total mucosa of the small intestine can produce any upset of absorption. With our present knowledge we presume that the remainder of the mucosa is normal, and thus the significant fact with reference to the commonly observed anaemia is the finding of Mayo and Nettrour (1936) that in all their cases the test for occult blood was strongly positive.

Abdominal symptoms and signs appear later. In some cases the site and character of the tumour influence the type of symptoms produced: thus a high tumour may give earlier gastric upset with nausea and pain occurring at a variable time after meals and accompanied by atonic dyspepsia. In more distally situated growths gastric symptoms may be more fleeting and therefore less noted; in consequence, when first seen these cases may present a palpable mass. Cameron (1938), in reviewing 200 cases of malignant small-bowel tumours, found that 65 per cent of sarcomata and 29 per cent of carcinomata were palpable. The higher incidence of palpable sarcoma is explained by the fact that the majority are more distally placed

and sarcomatous growths are usually of large size, carcinoma being small. The mass is generally mobile and frequently tender.

As mentioned above, it has frequently been suggested that the more proximal the tumour the earlier the gastro-intestinal symptoms occur, but this has not been confirmed by the more recent work of C. W. Mayo (1940), who found that the type of onset was not affected by the site.

Changes in bowel habit are common, usually as increasing constipation, though not infrequently as alternating constipation and diarrhoea.

Once gastro-intestinal symptoms are established they usually take the form of recurring attacks of intestinal obstruction with sudden severe cramps in the central and lower abdomen, accompanied by nausea and vomiting and a feeling of abdominal distension with borborygmi. Weeks or months may pass between each attack.

Some cases are first seen as cases of intestinal obstruction, which, if acute, will show the usual picture of vomiting, cramp-like pains, abdominal distension, and visible peristalsis. A few are first seen as perforations—2 cases, and possibly 3, in this series were such.

X rays have a very definite place as an aid to diagnosis of malignant small-bowel tumours. In any case of persistent unexplained melæna in which X-ray investigation of the stomach and colon shows no abnormality, and provided there is no acute intestinal obstruction, a full X-ray investigation of the small intestinal tract is indicated. In those cases in which an element of obstruction is present the most suitable, and the least dangerous, method would appear to be that favoured by Simpson-Smith (1939), C. W. Mayo (1940), and Frank, Miller, and Bell (1942). An Abbott and Johnston small double-lumen tube is swallowed. Once the pylorus is passed a balloon at the distal end of the tube is inflated and carried down the intestine by peristalsis (the bowel being decompressed *en route*) until it is arrested by the tumour, when a small quantity of a thin solution of barium sulphate can be instilled and the tumour outlined. This method has the additional advantage of allowing the bowel proximal to the tumour to be cleansed by lavage.

Where intestinal obstruction is not present an aqueous suspension of barium sulphate by mouth is recommended and watched frequently as a "small-bowel study". In the opinion of Å. Åkerlund (1932) it is now quite possible to make an X-ray diagnosis by accurate examination technique at a relatively early stage before any marked obstruction has had time to develop. He advises that the patient lies on his right side immediately after the meal and for some time. During the first hour brief screening examinations and survey exposures are taken at frequent intervals (with secondary diaphragm and broad girdle compression). The cardinal features in the early case are: (1) obliteration of normal

rugæ, (2) stiffness of the affected portion of the intestine, which is unyielding and tender to pressure, (3) filling defect, (4) peristalsis forming pseudo-diverticula. In his paper he shows 4 cases with undoubted X-ray local signs of tumour infiltration.

Mayo and Nettrour (1936), in reviewing 31 cases of carcinoma of jejunum at the Mayo Clinic, found in 10 cases positive X-ray evidence of tumour. They quote Gabor and Hiller for the opinion that retention of barium in the small intestine for more than eight hours is suspicious.

Good and MacCarty (1942) reported 22 positive findings out of 25 "small-bowel studies" with contrast medium examined by them at the Mayo Clinic.

Cameron (1938), in reporting 4 cases, had positive tumour findings in 1 case and possibly in another.

Other authors reporting positive X-ray findings include Palumbo (1933), Proescher and Muir (1935), Mitchell Heggs (1937), Craig (1941), and Hamilton, Kennedy, and Herauld (1944).

Weber and Kirklin (1942) reviewed the X-ray statistics at the Mayo Clinic, 1930-1939, when 17,000 cases of duodenal ulcer were correctly diagnosed; despite this large 'turnover', out of 36 cases of malignant small-bowel tumours the lesion was 'noted' in 94 per cent in the duodenum, 85 per cent in the jejunum, and 67 per cent in the ileum.

I have discussed at some length the X-ray investigation of these cases, because it must play a great part in attaining the pre-operative diagnosis. One ventures to suggest that a Miller-Abbott tube with suction and lavage might be used with benefit in many cases of acute intestinal obstruction to cleanse as far as possible the bowel lumen and contents before submitting the patient to operation, and to supplement the other more usual pre-operative measures of intravenous therapy, etc., for few surgeons can be proud of their operative mortality figures in acute small-bowel intestinal obstruction.

It is worthy of note that C. W. Mayo in 1940 found that an actual or tentative diagnosis of small-bowel malignant tumour had been reached in 25.7 per cent of 101 cases at the Mayo Clinic.

## PATHOLOGY

There is considerable variation in the reported frequency of the two principle malignant tumours of the small intestine, carcinoma and sarcoma. The former occurs more frequently than the latter. C. W. Mayo (1940), in reporting 108 cases at the Mayo Clinic, 1907-1939, found 80 cases of adenocarcinoma and 10 of sarcoma (in 16 there was no histological examination); and Cameron (1938), in reporting 200 cases, found 109 carcinoma and 78 sarcoma cases (the remaining 13 were described as malignant carcinoids).

In the present series 12 were carcinoma and 9 sarcoma.

The site of the tumours is also subject to variation. Bland-Sutton (1914) declared that cancer of the small intestine was commonest in the duodenum. Johnson (1922) expresses the opinion that, if one excludes the ampullary region, cancer of the duodenum is almost unknown. At the present time this statement appears to be misleading. Mayo and Rankin (1930) state that the incidence of cancer is highest in the jejunum. Berger and Koppelman (1942) report 1 case of carcinoma in the infrapapillary region and have found, reported, and proved 386 cases of duodenal carcinoma (77 suprapapillary, 251 peripapillary, and 58 infrapapillary); Cohn (1944) added 2 carcinoma cases in the suprapapillary portion.

C. W. Mayo (1940) in 80 cases of carcinoma found the incidence to be duodenum 23, jejunum 31, and ileum 21; in 5 the site was not specified. In Cameron's series of 109 cases of carcinoma, none were duodenal, 70 were jejunal, and 35 ileal.

The common site for sarcomata is ileal. Out of 78 cases, Cameron (1938) found 33 were jejunal and 42 ileal. Sarcoma of the duodenum appears to be excessively rare, though Simpson-Smith (1939) reported 3 such cases in a series of 70, while Frank, Miller, and Bell (1942) found as many as 21 out of 102.

Table I shows the distribution and pathology of the cases here reported.

Table I.—SITE AND PATHOLOGY OF 21 CASES

SITE	TOTAL CASES	ADENOCARCINOMA	SARCOMA
Duodenum	0	0	0
Jejunum	7	4	3
Ileum	13	7	6
Small intestine (part not stated)	1	1	0
Total	21	12	9

Table II gives details of the different types of carcinoma and sarcoma.

Table II.—PATHOLOGIC LESION AND PERCENTAGE (21 CASES)

GROSS TYPE OF TUMOUR	NO. OF CASES	PERCENTAGE	TUMOUR SUB-GROUPS
Carcinoma	12	57	Adenocarcinoma 8 Papillary adenocarcinoma 1 Alveolar carcinoma 3
Sarcoma	9	43	Reticulum-cell sarcoma 4 Lymphosarcoma 3 Fibrosarcoma 2 Leiomyosarcoma 0

**Carcinoma.**—The common type of carcinoma found is of the constricting ring variety similar to that type so frequently found in the distal



half of the colon and presenting the histological picture of a columnar-celled adeno-carcinoma. Nickerson and Williams (1937) state that infiltration of submucosa occurs early but that the muscularis mucosa and the muscle coats are more resistant and are not involved till later. They believe that involvement of the serosa is rare. Sometimes the growth develops in a polyp, and according to Mitchell Heggs (1937) this is the more usual type in the younger age groups. Whatever form the primary growth may have with the passage of time it tends to ulcerate and undergo colloid degeneration.

At operation the tumour is generally found already to have encircled the bowel completely and usually involves by its growth the relatively short distance of an inch or two of the bowel, and not infrequently its extent is a fraction of that area as is well shown in *Case 5* of this series (see *Fig. 421*). However small the tumour is, by the time it is first seen it has generally brought about complete, or very nearly complete, occlusion of the bowel lumen. The late onset of symptoms in these cases is accounted for by the fluid nature of the bowel contents at this level, and in consequence many of these cases first present themselves for treatment as cases of chronic or acute intestinal obstruction. In consequence of this gradual onset of obstruction, dilatation and hypertrophy of the proximal loop is a frequent finding.

An occasional complication of the annular type of tumour is the occurrence of intussusception, as is well shown in *Case 3* (*Figs. 417, 418*), in which the intussusception extended for 6 in. and was not completely reducible at operation. Black (1944) describes a case of low-grade polypoid adenocarcinoma which was thought to have caused attacks of intussusception for several years.

Intussusception is naturally a more frequent occurrence in the polypoid type of tumour. Bland-Sutton (1914) reports an interesting case of a man with disseminated melanoma who was admitted to the Middlesex Hospital with intestinal obstruction and was considered too ill for operation. Later his condition improved and he "passed" a length of bowel covered with melanoma deposits. Foster (1944) reports the occurrence of intussusception of a carcinomatous polyp in both father and daughter. Perforation through the tumour or the adjacent wall occurs infrequently. Mitchell Heggs (1939) quoted Venot and Parcellier as being able to find only 2 instances of perforation. Johnson (1922), however, refers to 3 cases of perforation in the museum of University College Hospital (drawings by Sir Robert Carswell).

Although intestinal symptoms develop relatively late, secondaries occur early. The early onset of secondaries is no doubt due to the abundance of the vascular and lymph-supply, combined with the well-developed absorptive function of the bowel at this level. Mayo and

Netttrou (1937) found secondaries in 50 per cent and quote Craig's figures of 11 out of 12 cases.

Metastases are found in the related lymph-nodes and peritoneum, in the liver, lungs, long bones, and dura in that order of frequency. In this series, 7 out of the 12 cases of carcinoma showed secondaries.

**Sarcoma.**—Sarcoma of the small intestine may be annular and constrictive, polypoidal, or tubular. The last type converts several inches of the bowel into a rigid tube, as in the case reported by Cope and Grant (1942) in which 10 in. of the bowel were thus altered, the wall in places being thickened to as much as 2 in., while the lumen was still fully  $\frac{3}{4}$  in. in diameter.

The annular type closely resembles in appearance the annular type of adenocarcinoma. *Case 6* shows a very narrow tightly constricting annular growth situated four feet from the ileo-cæcal valve, thought at operation to be carcinomatous, but which subsequent histology proved to be a sarcoma. Once again this emphasizes the importance of histological examination in these cases, for macroscopically similar obstructive lesions may be tuberculous.

The obstruction effect of these annular growths may be made more complete by pressure of adjacent and involved lymph-glands.

The tubular type of growth may also cause acute intestinal obstruction. This may be due to one of two causes. The common type of tumour usually starts in a lymphoid follicle in the submucosa, from which it spreads along the submucosa and eventually invades the muscle coat. Because the tumour cells neither elicit nor form much collagen, there is little tendency for constriction to take place (Cheever, 1933); instead the tumour has the effect of weakening the muscle, if not actually paralysing it, and so causing dilatation, with resultant stasis of the bowel content. Alternatively, the stasis and consequent intestinal obstruction may be brought about by the destruction of the nerve-plexus, with resultant paralysis of that segment of bowel.

Aneurysmal dilatation at the site of tumour is a frequent occurrence and is said by some authors to be more common than the annular constriction variety; Ullman and Abeshouse (1932), however, found 37 cases of stenosis as against 18 cases of dilatation, while Weinstein (1933) found an equal incidence.

Perforation of the tumour or the adjacent wall occurs rarely. Of the 9 sarcomata reported in this series 3 were perforated (e.g., *Case 2* and *Case 8*). In discussing this complication and reporting 1 case, Lewis (1939) was able to find only 6 cases out of 400 sarcomata recorded in the literature. Ullman and Abeshouse (1932) found 2 cases of perforation in their review of 126 cases.

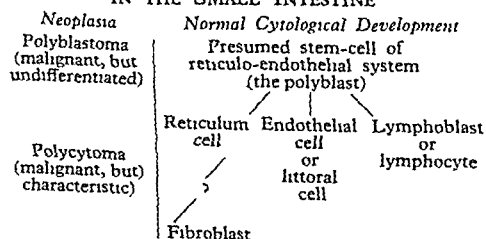
Metastatic growths seem to be commonest in the cases with sarcoma, and Ullman and Abeshouse (1932) found secondaries in almost every case.

When the classification of intestinal sarcomata is reviewed one is faced with much conflicting material. In 1932 Ullman and Abeshouse suggested that all the sarcomatous tumours be designated lymphosarcomata until the true relationship of the lymphocyte to the reticulum cell be established. In 1938 Cameron classified the sarcomata as fibrosarcoma, leiomyosarcoma, and malignant lymphoblastoma, the latter group including lymphosarcoma, lymphadenoma, and reticulo-endothelioma; he points out that many of the lymphoblastoma group are so inter-related that histological subdivision is frequently unjustifiable. In his review of 78 cases he classifies 49 as lymphoblastoma, and of these he accepts 43 as lymphosarcoma. In 1939 Lincoln Lewis quoted Ewing's classification of leiomyosarcoma, mixed-cell sarcoma, and lymphosarcoma. Morison (1941) suggests that the term 'reticulum-cell sarcoma' be applied to all tumours arising from the reticulum or its lymphoid derivatives, maintaining that there is little purpose in much subdivision when all are transitions and a single tumour may show more than one stage. Warren and Lulenski (1942) describe malignant lymphoma, Hodgkin's disease, lymphosarcoma, and reticulum-cell sarcoma, while Frank, Miller, and Bell (1942) subdivide 102 sarcomata into three main groups, nearly 70 per cent of which are included in the first main group of lymphosarcoma and reticulum-cell sarcoma, 22 per cent are included in the second group of leiomyosarcoma and myosarcoma, while the residue are in the third group of fibro-, neurofibro-, and spindle-cell sarcomata.

There appears to be a definite relationship between the subgroups lymphosarcoma and reticulum-cell sarcoma, and probably a connexion between them and Hodgkin's disease of the intestine. In view of this it would seem desirable to call them, as Cameron (1938) did, malignant lymphoblastoma, the classification being completed by the less frequent types of leiomyosarcoma and fibrosarcoma.

The surgeon desires to adopt a terminology which to him will be self-explanatory and one which will neither inhibit further questioning nor prove too false if later research by the pathologists should establish the connexion which at the moment they apparently suspect.

#### SUGGESTED SCHEME FOR CELLULAR SARCOMATA IN THE SMALL INTESTINE



It may therefore be suggested that the malignant undifferentiated tumour arising presumably

from the polyblast (the primitive lymphosarcoma of earlier writers) be called meanwhile the polyblastoma, and the more differentiated tumours of the group—the reticulosarcoma (producing argyrophil reticulum), the reticulo-endothelioma (forming sheets of cells), and the lymphosarcoma (cells resembling fairly adult lymphocytes)—be grouped as the polycytoma. Lymphadenoma should as yet be classified separately.

#### TREATMENT

The treatment of choice is resection of the affected loop of bowel along with a wedge of related mesentery and contained lymphatics. Continuity of bowel is re-established either by an end-to-end or a lateral anastomosis. Rankin and Mayo (1930) favour the former as giving a better chance of an aseptic field.

After operation Heggs (1939) advises continuous pernasal aspiration in addition to the usual intravenous therapy.

Johnson (1921) favours jejunostomy, but insists on the necessity of an anastomosis within 14 days. Jejunostomy in cases with acute obstruction was found by D'Allaines, quoted by Heggs (1937), to give a mortality-rate of 75 per cent.

Resection and anastomosis is by no means always possible, and C. W. Mayo (1940) gives figures for the Mayo Clinic similar to those of the other writers with fewer cases: in 42.4 per cent resection was possible, but in 41.3 per cent a palliative entero-anastomosis or other procedure was all that could be done, while 16.3 per cent were closed without further procedure.

Post-operative or palliative X-ray therapy is recommended by many writers, particularly American writers. Hundley and Bates (1938) report a case of jejunal cancer with many regional nodes and one nodule in the liver. The tumour was resected along with the involved glands and post-operative X-ray therapy given, the patient being alive and well three years later. Others favouring post-operative therapy include Weeden (1929), Ullman and Abeshouse (1932), Cameron (1938), Shulman (1941), Cope and Grant (1942), and Frank, Miller, and Bell (1942). All these authors stress particularly the use of X rays in sarcoma. In sarcoma some authors believe that all cases should have X-ray therapy whether the case has been operable or not; in the latter, it is stated that radiotherapy alleviates the symptoms, diminishes the size of the tumour, and improves the patient's general condition, although it has little, if any, effect on the duration of life. McSwain and Beal (1944) report that two cases (one had a resection and both had X-ray therapy) are surviving after nine years.

In the present series of 21 cases (no clinical records available in 3 museum specimens) 15 operations were performed: in 13 a resection and anastomosis was carried out; in 1 case a two-stage procedure was done, first a lateral

anastomosis to short circuit the tumour, followed 14 days later by resection of the tumour; the other operation consisted of simple drainage of a pelvic abscess.

Of these 15 cases 9 died within 14 days, giving an operative mortality of 60 per cent; 2 of these cases, and possibly 3, had perforated before admission to hospital.

Of the 10 carcinoma cases submitted to operation the operative mortality was 50 per cent; of the sarcoma cases it was 75 per cent.

In assessing the operative mortality it is as well to bear in mind that when first seen 6 cases, because of the seriousness of their condition, required immediate operation.

**Operative Mortality.**—The immediate operative mortality reported in the literature varies, and, according to Hundley and Bates (1938), is doubled in the presence of acute intestinal obstruction from 18 per cent to 36 per cent. At the Mayo Clinic in 31 cases of jejunal cancer Mayo and Nettrour (1937) give the operative mortality as 20 per cent. Cameron (1938), in his review of 200 cases of carcinoma and sarcoma, reports an immediate operative mortality of 30 per cent.

### PROGNOSIS

Prognosis is bad; the immediate because of the degree of obstruction when first seen by the surgeon, the late because of the high frequency of metastasis.

Wakeley (1932) reported a case well eight years after resection of terminal ileum for adenocarcinoma. He had the somewhat unique experience of exploring the abdomen at that time while repairing an umbilical hernia. He could find no evidence of secondaries.

Mayo and Nettrour (1936), in their series of 31 cases, report 2 cases surviving more than seven years, and 1 case which survived for seven years.

Cameron (1938), in his review of 200 cases, found the survival-rate as follows:—

SURVIVAL RATE IN 200 CASES  
(Cameron)

	3 Years	5 Years	8 Years	20 Years
Carcinoma	13	6	1	0
Sarcoma	10	10	3	1
Total	23	16	4	1

In this series, of the 6 cases successfully operated on 1 was a sarcoma and 5 were carcinoma. The sarcoma case developed secondaries and died in three years. Of the 5 carcinoma cases, 1 developed secondaries within one year, 2 remained well for 2½ years (1 put on 35 lbs. in weight), at which time secondaries became obvious or were presumed. One is still well 2½ years after operation and has gained 37 lbs. in weight. The longest survival was nine years. This case succumbed following the operation of right hemicolectomy for a carcinoma of the

cæcum nine years after resection of small-bowel carcinoma. Unfortunately, at the time of his second operation and death, it was not known that he had had a small-intestinal carcinoma removed at his first operation. In reviewing this case now it is thought that the cæcal carcinoma may have been a secondary growth, although at the time it was considered to be a primary.

### CASE REPORTS

**Case 1.**—A male patient, aged 62, was admitted to hospital on March 7, 1942, with a history of 18 months' duration, commencing with loss in weight. After 13 months he began to have gurgling sounds in his abdomen after food; not till one month later, that is four months before admission, did he begin to have pain. This pain came on 15 minutes after food and was relieved by alkalis and by lying on his right side. The pain was situated in the lower epigastrium and upper umbilical region, but latterly it was situated more in his left side. For one day, 14 days previously, he vomited after every meal, but apart from this he had had no vomiting. His appetite had been good, but he was afraid to eat because of the pain; recently he had heartburn but not water-brash. Bowels had always been constipated, but were worse lately. He had noted no change in the colour of the stools.

**ON EXAMINATION.**—Intelligent patient of good colour who showed evidence of considerable weight loss. The abdomen moved freely with respiration and there was no rigidity. A tender mass was palpable in the epigastrium and left hypochondrium. No liver enlargement was found. Barium meal showed a "normal stomach and duodenum". Test-meal showed hyperchlorhydria with rising curve.

**OPERATION** (Prof. Illingworth).—On March 11 the abdomen was opened through a midline epigastric incision. In proximal jejunum 3 in. below the duodenojejunal junction there was a massive primary

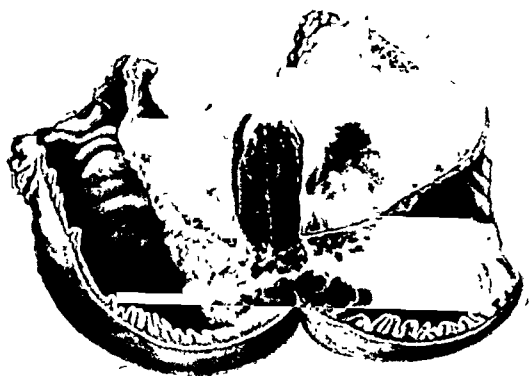


FIG. 414.—Case 1. An annular carcinoma completely occluding the lumen of the small bowel and invading the mesentery.

growth, 2 in. in diameter, which appeared to be causing stenosis. It was involving adjacent mesentery to some extent, but no enlarged glands were felt at this region; one gland was present proximally in relation to the third part of the duodenum.

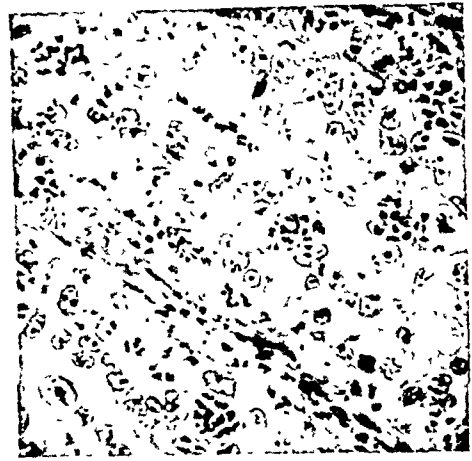
The affected segment of jejunum was isolated by division of its mesentery, with care to preserve the

superior mesenteric vessels. The intestine was divided above and below the tumour and the ends infolded. Proximally the point of division was at the duodenojejunal flexure (after freeing its attachments). A lateral anastomosis was made between

a quantity of thin purulent fluid escaped. No ulcer was found in the duodenum. The appendix was adherent to cæcum, but was obviously not the cause of the trouble. There was a general peritonitis. When the small bowel was examined a tumour was



A



B

FIG. 415.—Case 1. Sections showing invasion of the small-bowel mesentery by cancer cells. A,  $\times 75$ ; B,  $\times 225$ .

the third part of duodenum (after mobilization) and the jejunum some 6 in. below the level of resection. The enlarged gland previously noted was removed and the wound closed.

PROGRESS.—He made an uneventful recovery and was dismissed well on the twentieth post-operative day. At the end of nine months he had put on 37 lbs. in weight and is still well after 2½ years.

THE SPECIMEN (Fig. 414).—The segment of bowel has been opened in its entire length to show an annular type of tumour about 2½ in. in length which is completely occluding the bowel lumen. The tumour has penetrated widely through the muscle layer and has extensively invaded the mesentery. The proximal loop is dilated and shows some muscle hypertrophy.

Histological examination confirmed the diagnosis of adenocarcinoma which had metastasized to the lymph-gland (K. Fraser) (Fig. 415).

Case 2.—A male, aged 51, was admitted to a nursing home with a history of many years of indigestion which was investigated some years ago. His own doctor had been looking after him for some time and had seen him the night before and had advised that he should have an X-ray examination. At 8 a.m. on the morning of admission he was seized with acute abdominal pain, which started in the epigastrium but later shifted to the right iliac fossa. He was seen some hours later by his doctor, who advised immediate operation. He gave a history of some loss of weight.

ON EXAMINATION.—T. 99.6, P. 100, R. 22. He looked very ill. His tongue was dry and the abdomen distended. No mass was palpable and there was no localized rigidity. Tenderness was marked in the epigastrium and down the right side. The diagnosis was thought to be a perforation of a duodenal ulcer rather than an appendix, although the picture fitted neither and something "out of the way" was suspected.

OPERATION (Mr. A. J. Hutton).—Right paramedian incision. When the peritoneum was opened

found encircling the bowel 6–8 in. below the duodenojejunal junction. There appeared to be some leakage from the tumour. At the root of the mesentery in the line of the drainage there was a large glandular mass. This was fixed to the posterior abdominal wall and aorta and was quite irremovable. A loop

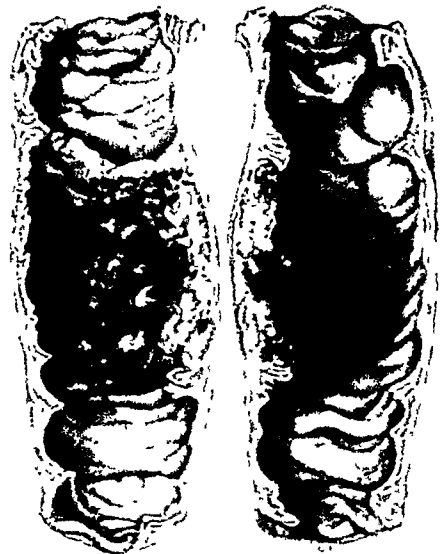


FIG. 416.—Case 2. A spheroidal-cell carcinoma of small bowel.

of bowel including the tumour was excised and an end-to-end anastomosis was performed. The abdomen was closed.

PROGRESS.—He had a bad cough following the operation; his condition deteriorated steadily and he died on the sixth day.

THE SPECIMEN (Fig. 416).—There is a tumour about 1½ in. in diameter arising from the mucosa

and spreading round the bowel wall, which it has not completely encircled. The tumour surface is slightly raised and irregular and shows deep congestion and areas of necrosis. At the centre of the growth the muscle layer has been penetrated, the tumour tissue having reached the serosa.

**Histological Examination** (Dr. N. G. B. McLetchie).—This showed the structure of a very cellular rapidly growing spheroidal-cell carcinoma with invasion of lymph-glands.

**Case 3.**—A housewife, aged 64, was admitted to hospital with acute central abdominal pain of 18 hours' duration. The pain was accompanied by a feeling

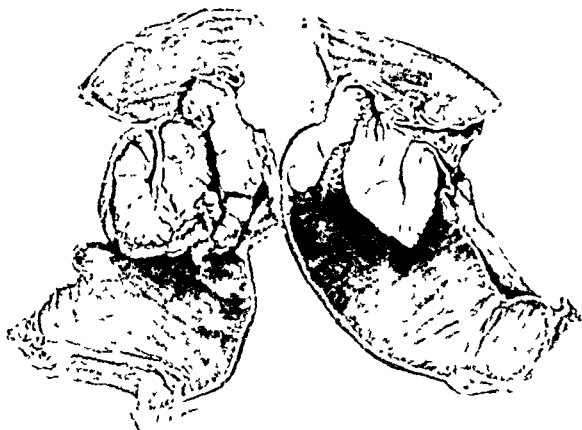


FIG. 417.—Case 3. An adenocarcinoma of polypoidal type which has caused intussusception of the small intestine.

of abdominal distension and vomiting occurred two hours before admission. She had felt "off colour" for several months and was under treatment from her own doctor for anaemia and a ventral hernia. Her



FIG. 418.—Case 3. The same specimen as in Fig. 417, showing the external appearance.

appetite had been poor and she had been losing weight for some time. Constipation had been troublesome, but her bowels moved the day before admission.

**ON EXAMINATION.**—She was found to be a pale, thin, anæmic woman, showing evidence of marked loss of weight. A mass was palpable to the left of the umbilicus in a moderately distended abdomen. No umbilical or femoral hernia was found. Rectal examination was negative. Next day, the day before operation a preliminary X-ray film showed "a

large area of bowel distended with gas". Barium enema passed freely to the terminal ileum, revealing no obstruction in large bowel.

**OPERATION** (Mr. J. Mill Renton).—The abdomen was opened through a left paramedian incision. About 10 ft. from the ileocecal junction an intussusception of small intestine was found, 6 in. in extent and with marked distension above the obstruction. The intussusception could be reduced in part only, complete reduction being prevented by adhesions at its neck. The affected portion of small intestine was excised and a lateral anastomosis was performed. The wound was closed.

**PROGRESS.**—She was making quite good progress until the eleventh post-operative day, when her wound burst. She died on the fourteenth day.



FIG. 419.—Case 3. Columnar-celled adenocarcinoma which has spread through the muscularis mucosa and has invaded the muscle layers. Normal bowel on the right is seen to merge into tumour tissue. A,  $\times 18$ ; B,  $\times 93$ .

**THE SPECIMEN** (Figs. 417, 418).—There is an annular tumour involving the entire circumference of the bowel and producing almost complete occlusion. The tumour has formed the apex of the intussusception, which is still partly in evidence.

**Histological Examination** (Dr. Marion K. Gilmour).—"The intussuscepted portion of small bowel contains an adenocarcinoma invading fairly deeply through muscle. Several enlarged mesenteric lymph-glands show inflammatory reaction, but no metastatic deposit". (Fig. 419.)

**Case 4.**—A female, aged 41, was admitted to hospital with a history that four months previously she had suddenly developed pain in her back and round her right side. This pain became progressively

# MALIGNANT TUMOURS OF SMALL INTESTINE

487

worse and reached its climax about five hours later when she vomited. The pain then eased off, but she still felt her right side sore next day. At no time had the pain passed down into her groin and there was no upset of micturition. She had a further seven or eight attacks of these pains, which appeared to occur in spasms and which doubled her up. The last attack occurred three weeks prior to admission. During these attacks she was aware of "rumblings"

ON EXAMINATION.—He was found to be very thin, though not cachectic. The abdomen was somewhat distended and displayed very obvious small-bowel peristalsis. There was no palpable tumour.



FIG. 420.—Case 4. A columnar-celled carcinoma showing marked mucoid degeneration. The tumour has penetrated through the bowel wall. Normal bowel wall is seen at either end in the low-power view of the specimen. A,  $\times 1.8$ ; B,  $\times 45$ .

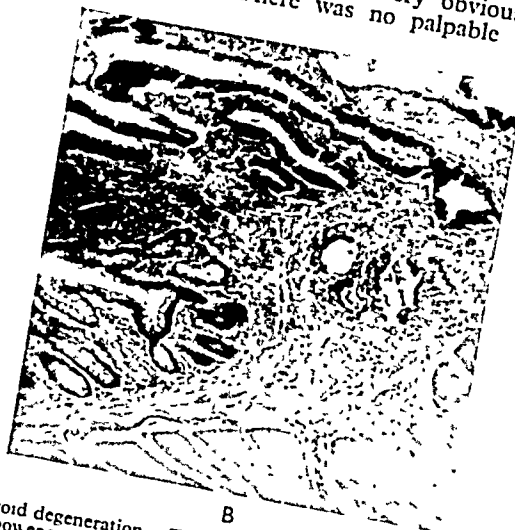


FIG. 421.—Case 5. An annular carcinoma of the small intestine, showing gross dilatation of the proximal loop.



in her abdomen. Her appetite was good and the pain appeared to have no relation to the taking of food. There was no indigestion and no fat dyspepsia. The bowels were regular, moving daily. No other relevant points were elicited.

ON EXAMINATION.—On admission she was healthy looking. Her abdomen moved freely on respiration and showed no guarding or rigidity. No mass was palpable. Seven days after admission she developed abdominal pain and vomiting which lasted five hours. Later, X-ray investigation proved the presence of normal kidneys and gall-bladder.

OPERATION (Mr. J. Scouler Buchanan).—Fourteen days after admission the abdomen was opened through a right paramedian incision. The rectus muscle was thin. The gall-bladder was normal. Large mass of glands in mesentery of terminal ileum arising from a tumour in ileum about 18 in. from ilio-cæcal valve; annular in character and causing chronic obstruction. A well-marked Meckel's diverticulum was found 6 in. proximal to the tumour. A resection of 15 in. of bowel including the diverticulum was carried out. The ileum was anastomosed to ascending colon by a lateral anastomosis.

HISTOLOGICAL EXAMINATION (Dr. N. G. B. McLetchie).—"This is a mucoid adenocarcinoma with spread through the bowel wall." (Fig. 420.)

PROGRESS.—The wound was rather slow to heal, but she recovered well and was dismissed on the twenty-fourth day. She had reported well and with no evidence of recurrence when seen nine months later. Now after two years she is losing weight and complains of backache and diarrhoea, which suggest that secondaries have developed.

Case 5.—A male, aged 48, had noticed that for one year he had been losing weight and had lost about 40 lb. For nine months he had repeated attacks of vomiting every two or three days. He noticed that the vomit was very copious and consisted of bile-coloured fluid. Between these attacks his appetite was good. At no time had he any abdominal pain.

He was given plasma and saline-glucose intravenously.

OPERATION (Prof. Illingworth).—Right paramedian incision. The growth was of small size, about 1 in. in diameter, forming a very tight stricture and causing almost complete obstruction. Its precise situation could not be established, but it appeared to be approximately at the midpoint of the small intestine. The bowel above was immensely distended and very

hypertrophied. There were no glands involved and no palpable metastasis in the peritoneum or liver. The growth appeared to be a carcinoma of small intestine. The affected segment of intestine was excised along with a V-shaped portion of the mesentery. The two ends were closed and a lateral anastomosis was then performed.

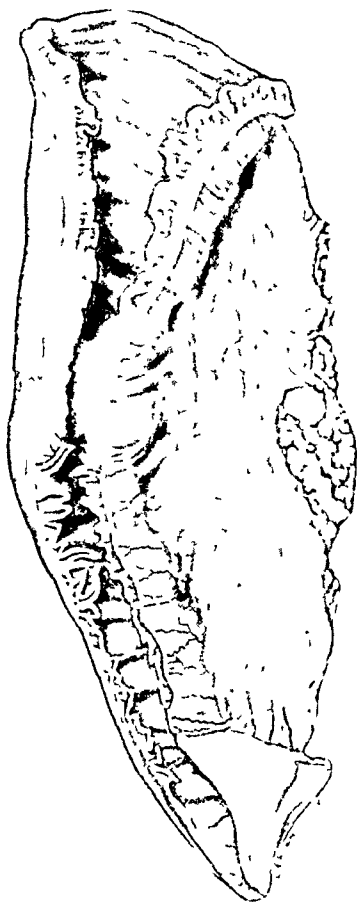


FIG. 422.—Case 6. An annular type of reticulum-cell sarcoma of the terminal ileum. The invaded gland can be seen in the cut surface of the mesentery.

**PATHOLOGICAL REPORT (K. Fraser).**—This specimen shows huge dilatation and some hypertrophy of the proximal loop of small bowel. There is an annular growth at the lower limit of the dilatation which has completely occluded the bowel lumen. The tumour is only  $\frac{1}{2}$  in. wide (Fig. 421). The histological picture was that of a fairly well-differentiated adenocarcinoma, with invasion of the muscle layer at one point. Mitotic figures are not a prominent feature.

**PROGRESS.**—Immediate progress excellent. No vomiting and rapid recovery. Bowels opened well on fourth day after aperients, the appetite was returning, and the patient was feeling very well. On the evening of the sixth day he complained of sudden pain referred to pubic region and scrotum. This was followed by two normal bowel movements. He felt collapsed, but improved after stimulants. One hour later he suddenly fell back unconscious. Seen shortly afterwards he was found to be cold and

almost pulseless. Heart-rate was about 90 and very faint; respirations normal. He later regained consciousness and understood questions, though he answered with difficulty and incoherently. No facial paralysis or paralysis of limbs. Both pupils were completely inactive to light. At first the right pupil was dilated and the left contracted; later both were dilated. Two pints of plasma and three pints of glucose-saline were given intravenously. This improved the pulse very slightly, but the improvement was not maintained and he died five hours later. At no time did he complain of pain in his chest or side. There was no post-mortem.

**Case 6.**—A female patient, aged 61, was admitted to the medical wards of the Western Infirmary with a four months' history of attacks of central abdominal discomfort and pain unrelated to meals but accompanied by vomiting which relieved the pain. The attacks of pain came in "waves" which lasted about five minutes and with a period of freedom of the same duration. During the attacks she had diarrhoea. For some time she had been conscious of rumblings in her abdomen and had been losing weight. After admission the vomiting, which had been bilious, became faecal and she was transferred to the surgical wards. A barium meal six days previously showed a normal stomach and duodenum.

**EXAMINATION.**—On admission to the surgical wards she was found to have a dry yellow skin with marked loss of subcutaneous fat. The abdomen was distended mainly in the centre, but also in the right flank. The distension at times appeared to have a ladder pattern. No mass was palpable and

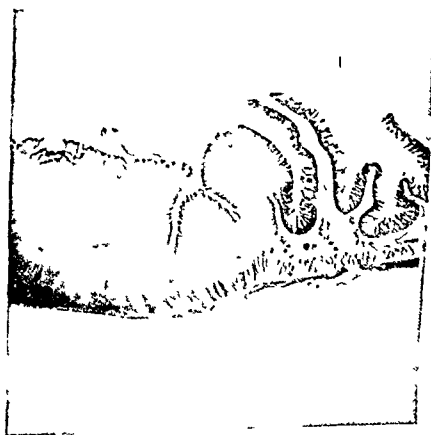


FIG. 423.—Case 6. Shows all the layers of bowel wall diffusely invaded by reticulum-cell sarcoma. ( $\times 3$ )

there was no tenderness or rigidity. There was no shifting dullness. She was given pre-operative intravenous therapy, etc., and was operated on the next morning.

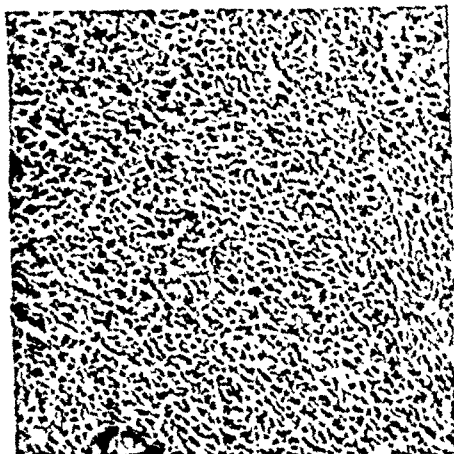
**OPERATION (Prof. Illingworth).**—Under spinal anaesthesia, supplemented by gas and oxygen, the abdomen was opened through a right paramedian incision. About 4 ft. above the ileocaecal junction an annular tumour was found 2 in. in length and almost completely obstructing the bowel. Proximally the intestine was greatly hypertrophied and dilated for several feet. A few small glands were found in the adjacent mesentery, but no distant metastases were seen. The affected segment of

ileum, along with a wedge of mesentery including the glands, was excised, and a side-to-side anastomosis was carried out. The wound was closed.

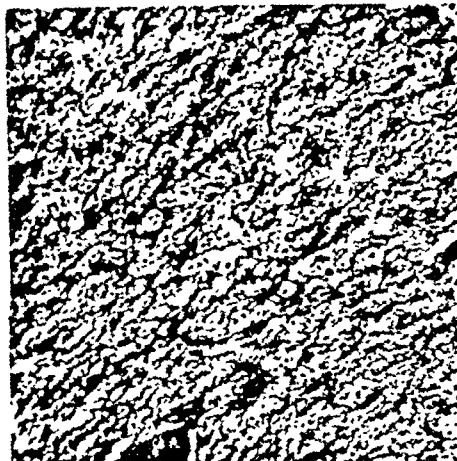
PROGRESS.—Her progress for several days was satisfactory until she developed a pelvic peritonitis and died on the tenth day.

THE SPECIMEN (Figs. 422-424).—There is an annular type of tumour about 2 in. in length which

abdominal pains and "rumblings" which started the day before admission. The pains were situated in the lower umbilical region and left iliac fossa. When the severe spasms passed off he felt a dull pain in the left iliac fossa. He had had no vomiting and his bowels had been regular. For 2-3 months he had felt slight colicky pains just above the inguinal ligaments. He thought he might have lost some weight.



A



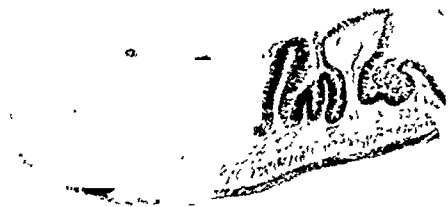
B

FIG. 424.—Case 6. A, Stained by H. and E., shows medium-sized oval and spindle cells associated with the light fibrillar stroma. B, Shows the same area stained to show reticulum. ( $\times 135$ )

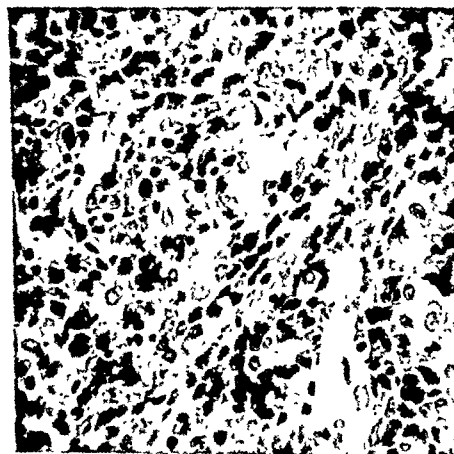
is almost completely occluding the bowel lumen. The tumour appears to be mainly involving the submucous coat of the bowel, with consequent elevation and thinning out of the mucosa. It has penetrated the muscle layer, which is thinned out and fragmentary, and is infiltrating the subserous coat. The proximal loop shows well-marked muscle hypertrophy and some dilatation; distally the bowel is collapsed. In the adjacent mesentery there is one enlarged and invaded gland.

Histological Report (Prof. J. Shaw Dunn).—"The tumour is composed mainly of oval or spindle cells of medium size associated with light fibrillar formation. It apparently arises in mucosa, possibly from

Artefact



A



B

FIG. 425.—Case 7. A, Reticulum-cell sarcoma densely infiltrating all the bowel coats ( $\times 225$ ). B, Medium-sized oval and spindle cells in a stroma of fine reticulum ( $\times 300$ ).

a Peyer's patch, and invades very diffusely through submucosa and muscularis to serosa. The muscularis mucosa remains identifiable and many of the crypts. From its structure and site, where it appears to have been primary, I regard this as most probably a reticulum-cell sarcoma growing from lymphoid tissue."

Case 7.—A male, aged 60, was admitted to hospital on Aug. 27, 1937, with severe colicky VOL. XXXII—NO. 128

seen below the umbilicus and was passing from right to left. No mass was palpable, but there was tenderness in the left iliac fossa. Barium enema showed "delay and narrowing in the lower sigmoid with local tenderness at this point. The large bowel proximal to this area filled normally. The appearances suggest neoplasm of sigmoid."

OPERATION (Mr. W. Campbell).—On Sept. 3 the abdomen was opened through a left paramedian incision. Great distension was found in both large



and small bowel. An annular growth involving the terminal ileum and adherent to the bladder proved to be the cause of the small-bowel obstruction. The large-bowel obstruction was due to an adhesion. The terminal ileum, along with the tumour, was excised and a lateral anastomosis was carried out. A drain was inserted and the abdomen was closed. He died on the sixth post-operative day.

**Histological Examination** (Dr. J. F. Heggic).—"This is a cellular malignant tumour which has invaded the bowel wall, adjacent lymph-glands, and the tissue from behind the bladder. An opinion as to the nature of the growth cannot be given at present". (Fig. 425.)

This tumour is now considered to be a reticulum-cell sarcoma.

**Case 8.**—A male, aged 65, was admitted to Mr. Roy F. Young's wards in Western Infirmary with a

**POST-MORTEM EXAMINATION** (Dr. Marion K. Gilmour).—A quantity of free purulent fluid was found in the peritoneal cavity. The proximal small intestine was distended with greenish-yellow fluid. About 4 ft. from the duodenojejunal junction a 4-in. length of bowel was found to be firm and thickened;  $\frac{1}{2}$  in. distal to this mass there was a perforation of the bowel which was responsible for the peritonitis. On opening the bowel a pale infiltrative growth was found occupying some 3-4 in. of the bowel wall. Acute inflammatory congestion was also present. The distal bowel was collapsed. Two inches from the ileocaecal valve another patch of infiltrative growth was found,  $1\frac{1}{2}$  in. in diameter; this was not ulcerated. Many enlarged glands were found at the root of the lung; the largest of these showed a pale margin suggestive of surrounding infiltration.

**Histological Examination** of the bowel lesion and of the enlarged lymph-glands showed a rather

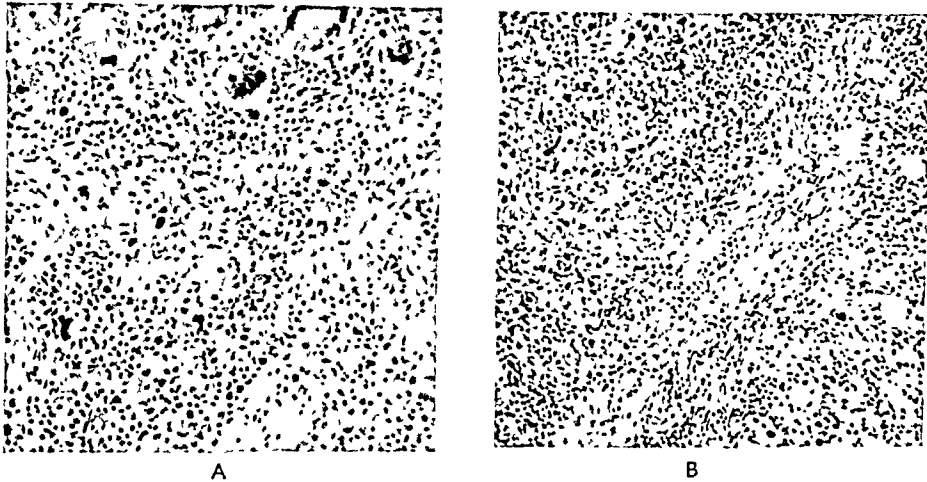


FIG. 426.—Case 8. A, Reticulum-cell sarcoma showing invasion of bowel wall. ( $\times 135$ .) B, A lymph-gland invaded by reticulum-cell sarcoma. The fine stroma shows fibrous changes in certain areas. ( $\times 112$ .)

history of one week's duration. During that time he had been feeling unwell, with loss of appetite and energy, and he had stayed off his work. For five days before admission he had suffered from hiccup, which had been continuous and had prevented him from sleeping. For three days he had generalized abdominal pain with vomiting, worse on the day of admission. He did not know what colour the vomit had been. His bowels had been constipated for some time and he had to take "medicine".

**ON EXAMINATION.**—T. 101, P. 124, R. 24. He looked ill, old for his age, and paid little attention to his surroundings; he was unable to co-operate or to give any clear history. His cheeks were sunken and drawn, and there was evidence of marked loss of weight. The tongue was furred. The abdomen moved freely on respiration and was not distended. A tender mobile mass about 2 in. in diameter was palpable in the left hypochondrium. There was no rigidity and no free fluid. He was considered too ill for operation, and although duodenal drainage and intravenous therapy were instituted he showed no improvement and died two days later.

A diagnosis of malignant small-bowel tumour was one of the possibilities considered in this case, probably due to the fact that this paper was being prepared at that time.

vascular cellular growth with invasion of the periglandular fat in the latter. The cells are variable in size, and there are many mitoses; they are separated by fine reticulum which becomes fibrous in areas.

This is a reticular-cell sarcoma (Fig. 426).

## SUMMARY AND CONCLUSIONS

1. A review of the literature on malignant small-bowel tumours is presented.

2. The pathology of these tumours is considered in some detail, and a classification of sarcoma tumours is suggested.

3. Thorough X-ray investigation of the small bowel is emphasized in all cases of melaena in which the radiologist has reported that the stomach and colon are normal.

4. The operative mortality in these cases is high owing to the late onset of commanding symptoms and to the fact that the surgeon only too frequently sees them first as cases of intestinal obstruction. The prognosis is poor because of the early spread of metastasis.

5. Twenty-one cases of malignant small-bowel tumours are described, 12 adenocarcinoma

# SPONTANEOUS RUPTURE OF A HYDRONEPHROSIS 491

and 9 sarcoma. Eight of these cases are described in detail and are accompanied by illustrations to show some of the types of tumour found and the complications which may occur.

My thanks are due to my colleagues of the Western Infirmary Staff, named in the text, for allowing me to use their cases and for their ready help and co-operation; to Mr. Roy F. Young and Prof. Illingworth for the use of their cases and for their assistance with this paper; and to members of the Staff of the Pathology Department of the Western Infirmary, particularly to Dr. Alan C. Lendrum, for kindly comments and most of the ideas incorporated in the discussion of the sarcoma.

The illustrations are the work of Miss C. Brown Kelly and Dr. N. Cowan; the photographs are by Mr. John Watt: to these I am greatly indebted for their care.

## BIBLIOGRAPHY

- ÅKERLUND, Å. (1932), *Zur. dir Rönt. Dumm.*, 71, 1.  
 BLACK, B. M. (1944), *Proc. Mayo Clin.*, 19, 142.  
 BLAND-SUTTON, SIR JOHN (1914), *Lancet*, 2, 931.  
 JERGER, L., and KOPPELMAN, H. (1942), *Ann. Surg.*, 116, 738.  
 CAMERON, A. L. (1938), *Ibid.*, 108, 203.  
 CHEEVER, D. (1933), *Ibid.*, 96, 911.  
 COHN, J. (1944), *Ibid.*, 119, 342.  
 COPE, Z., and GRANT, H. M. (1942), *Brit. J. Surg.*, 29, 365.  
 CRAIG, W. J. (1941), *Brit. J. Radiol.*, 14, 162, 210.  
 EWING, J. (1922), *Neoplastic Diseases*, 2nd ed., 662.  
 FOSTER, D. B. E. (1944), *Brit. med. J.*, 2, 78.  
 FRANK, L. W., MILLER, A. J., and BELL, J. C. (1942), *Ann. Surg.*, 115, 544.  
 GOOD, C. A., and MACCARTY, W. C. (1942), *Proc. Mayo Clin.*, 17, 20.  
 HAMILTON, J. B., KENNEDY, P. C., and HERAULT, P. C. (1944), *Ann. Surg.*, 119, 856.  
 HEGGS, F. M. (1939), *Brit. J. Surg.*, 26, 532.  
 — (1937), *Lancet*, 2, 1250.  
 HUNDLEY, J. W., and BATES, W. (1938), *Ann. intern. Med.*, 12, 128.  
 JEFFERSON, G. (1916), *Brit. J. Surg.*, 4, 209.  
 JOHNSON, R. (1921-2), *Ibid.*, 9, 422.  
 LEWIS, D. L. (1939), *Ibid.*, 26, 541.  
 MCSWAIN, B., and BEAL, J. M. (1944), *Ann. Surg.*, 119, 108.  
 MAYO, C. W. (1940), *Coll. Pap. Mayo Clin.*, 32, 312.  
 — — and NETTROUR, W. S. (1936), *Ibid.*, 38, 146.  
 — — (1937), *Surg. Gynec. Obstet.*, 65, 303.  
 MORISON, J. E. (1941), *Brit. J. Surg.*, 113, 139.  
 NICKERSON, N. A., and WILLIAMS, R. M. (1937), *Amer. J. Path.*, 13, 53.  
 PALUMBO, E. (1933), *Amer. J. Cancer*, 18, 717.  
 PROESCHER, F., and MUIR, J. (1935), *Ibid.*, 24, 1.  
 RANKIN, F. W., and MAYO, C. (1930), *Surg. Gynec. Obstet.*, 50, 939.  
 SHULMAN, S. (1941), *Amer. J. Roentgenol.*, 46, 182.  
 SIMPSON-SMITH, A. (1939), *Brit. J. Surg.*, 26, 429.  
 ULLMAN, A., and ABESHOUSE, B. S. (1932), *Ann. Surg.*, 95, 878.  
 WAKELEY, C. P. G. (1927), *Brit. J. Surg.*, 14, 525.  
 — — (1931), *Aust. N.Z. J. Surg.*, 1, 227.  
 — — (1932), *Lancet*, 2, 1158.  
 WARREN, S., and LULENSKI, C. R. (1942), *Ann. Surg.*, 115, 1.  
 WEBER, H. M., and KIRKLIN, B. R. (1942), *Amer. J. Roentgenol.*, 47, 247.  
 WEEDEN, W. N. (1929), *Ann. Surg.*, 90, 247.  
 WEINSTEIN, M. L. (1933), *Amer. J. Cancer*, 18, 716.

# SPONTANEOUS RUPTURE OF A HYDRONEPHROSIS

BY RONALD REID  
 SURGEON, BLACK NOTLEY EMERGENCY HOSPITAL  
 AND W. C. MENZIES  
 R.S.O., BLACK NOTLEY EMERGENCY HOSPITAL

TRAUMATIC rupture of hydronephroses have been recorded in the past, but the writers have been unable to discover in the literature a case of spontaneous rupture of a hydronephrosis, and they therefore feel justified in presenting the following case.

## CASE REPORT

HISTORY.—At 2 p.m. on Sept. 13, 1943, Sergeant R. F. H., aged 24, was admitted to hospital complaining of severe abdominal pain, nausea, and vomiting. Since 6 a.m. the patient had been riding in a lorry, sitting most of the time on a low seat with his hips and knees flexed. The lorry had travelled on main roads with fairly good surfaces; several stops had been made, and on each occasion the patient passed urine. He had had no food or drink since 10 a.m. At about 1 p.m. he started driving the lorry himself, and after a few minutes felt discomfort in the upper abdomen which rapidly increased and was described as a severe stomach ache. He stopped driving and rode in the back of the lorry again, but the

pain did not diminish and after a short time he had to call the lorry to a halt in order to descend to the road and vomit. The pain from that time increased rapidly, and on admission the patient was distressed and suffering great pain under the left costal margin, spreading round the flank and down across the abdomen.

On investigation of the past history the patient stated that seven years ago he started suffering attacks of severe pain under the left costal margin, which did not radiate round to the back or down to the groin. He felt as if there was something inside him which was blown up, and he always felt tender and bruised in the loin during and after an attack. Nausea was always severe and he usually vomited several times and was unable to eat or drink anything until after the pain had gone. The attack would last twelve to twenty-four hours and, although not always severe, was sufficient to keep him awake at night. There was no history of dysuria or frequency during or after an attack, but he sometimes noticed that the day before the pain started he would pass more urine than usual. These attacks occurred about once a month for three

years, but he was perfectly fit between them, and since joining the Army four years ago he had suffered only three attacks, the last being three months ago. There was no further past history of significance.

**ON ADMISSION.**—The patient's temperature was 96.7° F., his pulse 68, and respirations 22 per minute. He was distressed, his tongue was clean and moist, and his skin dry. His blood-pressure was 170/100. Examination of the abdomen showed a very small range of movement on respiration, with marked muscle guarding over the whole of the left side. On the right side there was no resistance and no tenderness. By 5 p.m. the pain had increased and the whole of the left side of the abdominal wall was rigid and immobile. Examination of the blood showed 4,400,000 red cells and 15,600 white cells per c.mm.; 80 per cent were polymorphs and the hæmaglobin was 90 per cent. At 6.30 p.m. the patient was catheterized, and 18 oz. of concentrated normal and sterile urine were withdrawn. No blood-cells were found on microscopy. By 7 p.m. his temperature had risen to 100° F. and his pulse to 90. The pain was still intense and by now the right side of the abdomen was involved in the spreading muscle rigidity, and tenderness was more marked. At this time rebound tenderness had made its appearance, and with the spreading rigidity, increase of pain, rising pulse, and rebound tenderness as guides it was thought justifiable to perform a laparotomy.

**FIRST OPERATION.**—At 8.30 p.m., under gas, oxygen, and ether anæsthesia the abdomen was opened by a midline epigastric incision by W. M. No gas or free fluid was found in the abdomen, the stomach and duodenum were normal, the lesser sac was explored and nothing abnormal discovered. The whole of the small intestine was inspected, and apart from some congestion of the upper coils of jejunum, nothing abnormal was found. The posterior abdominal wall was then examined and an oedematous mass situated in the region of the tail of the pancreas and the left kidney was seen. The oedema involved the peritoneum and underlying tissue and spread into the transverse mesocolon. The diagnosis was still in doubt, and the possibility of pancreatitis was kept in mind. The abdomen was closed without drainage, and at the end of the operation the patient's general condition was good.

**PROGRESS.**—On the following day the patient's condition was improving, but he still had pain in the upper left quadrant of the abdomen, and at times had spasms of pain and nausea. As he was unable to pass water he was catheterized, and 25 oz. of urine containing a great quantity of blood were withdrawn. Fluid by mouth was prohibited and glucose-saline was given by intravenous drip infusion. On the next day, Sept. 15, the patient was better, but was not yet able to pass urine and was catheterized; another 35 oz. of heavily blood-stained urine were withdrawn. His blood-pressure was now 170/110, and his blood-urea was 28 mg. per 100 c.c. In the evening he passed urine which was blood-stained, and the next day, although he was still having pain, his general condition had improved but his urine, which was passed freely, still contained blood. Two days later the patient's condition was very satisfactory, he was taking fluids by mouth, he had no nausea, his blood-pressure remained at 170/110; there was a trace of blood in the urine and the leucocyte count showed 88,000 white cells per c.mm.

On Sept. 20 the patient was almost symptom free, his urine was normal, but his blood-pressure remained at the same level. Ten days later, on Oct. 1, the patient seemed very well and his blood-pressure had

fallen to 120/80. By now the rigidity had completely disappeared and a tender thick mass was palpable in the situation of the left kidney. A descending pyelogram on Oct. 4 showed that the right kidney was normal and that no dye was secreted on the left side.

On Oct. 16 a cystoscopy was performed by one of us (R. R.), and the bladder and ureteric orifices were found to be normal in all respects. A catheter passed easily up the right ureter to the full distance, but on the left side it could not be inserted beyond about 15 cm. There was a copious efflux from the right kidney and a normal excretion time for indigo-carmin, but there was nothing whatever from the left side. A retrograde pyelogram was taken (Fig. 427), which shows that most of the dye has returned



FIG. 427.—Ascending pyelogram, left side, showing diffuse shadow.

alongside the left ureter and entered into the bladder, but a small amount has gone up to the renal region, where it seems to be diffused in the soft tissues and does not appear to outline any hydronephrotic sac. On the evidence accumulated so far, it was decided that this must be a case of rupture of the kidney, and as spontaneous rupture of a normal kidney was thought to be impossible, and in view of the fact that the right kidney was normal in function and outline, it was decided to explore the left kidney.

**SECOND OPERATION.**—On Nov. 2, under a unilateral spinal anæsthetic, the left kidney was explored after resection of the 12th rib. Nothing abnormal was encountered until the perinephric fat was reached, when oedema and a certain toughness was noted. The kidney capsule was exposed and the organ easily dissected free by gauze stripping as far as the upper pole, which was closely adherent towards the midline and enclosed in a firm fibrotic and oedematous mass the size of a tangerine orange. This mass seemed also to incorporate the left suprarenal capsule. By careful dissection the kidney was freed from its inclusion in this matted tissue, and now that it was easily visible, was found to consist of a hydronephrotic sac with what was apparently a perforation at the upper end. During the course of the dissection at the upper end, clear urine gushed freely into the wound. At the lower part of the tumour an aberrant renal artery and vein were found closely adherent and constricting the ureter just below the pelvi-ureteric junction. The kidney emptied of urine was found to be a flabby sac and was removed without the slightest

# SPONTANEOUS RUPTURE OF A HYDRONEPHROSIS 493

difficulty. The anaesthesia proceeded normally, and the only remarkable event was the sudden rise in blood-pressure when dissection at the upper pole of the kidney was carried out. The patient made an uneventful recovery.

**THE SPECIMEN.**—On examination of the specimen (Fig. 428) a large hydronephrotic sac was discovered

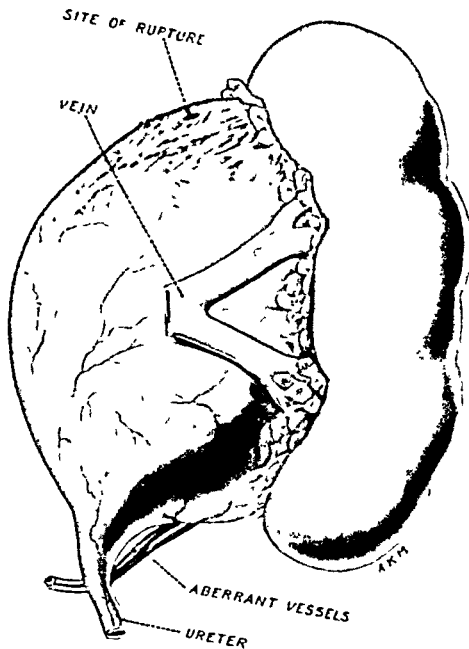


FIG. 428.—Drawing of the specimen after excision.

with a constriction at the pelvi-ureteric junction, and a definite round perforation near the upper pole apparently closed by a button of pink granulation tissue. Around this perforation the perinephric tissues were matted and oedematous. The pelvis itself was thickened, the calices were dilated and clubbed, and the renal cortex was reduced to a thin pallid shell.

## COMMENTARY

This case presents interesting features apart from the rarity of the condition. The first question to be answered is why the spontaneous rupture occurred, and it seems possible that as the man was sitting in a doubled-up position in the lorry he may have kinked his ureter at the site of the constriction and made complete an obstruction which was previously incomplete or intermittent. He then changed to driving the truck, and in flexing his thigh fully to work the heavy clutch the pressure in his kidney pelvis may have been raised to bursting point. The

patient states that the clutch pedal was a high one. Retroperitoneal extravasation of blood and urine from an injured kidney is not an uncommon condition, but the signs are nearly always those of extravasation plus those of the causative injury, which may, for example, be a crush or a bullet wound. In this case one can study the symptoms and signs resulting from extravasation unassociated with injury. This case supports the widely known fact that retroperitoneal extravasation gives rise to the same signs and symptoms in the early stages as does intraperitoneal extravasation. Abdominal movement is limited, rigidity develops and spreads, followed by tenderness and rebound tenderness. A retroperitoneal effusion of blood and urine therefore gives symptoms and signs of spreading peritoneal irritation. Why the extravasation did not continue to give rise to extensive retroperitoneal oedema may be owing to the fact that the sudden release of pressure resulted in the renal failure of the affected kidney. At all events the perforation seems to have healed. The profuse haematuria which followed 48 hours after the extravasation could not have arisen from a tear of the kidney cortex because it was undamaged, nor is it likely that such profuse haemorrhage could have come from the avascular pelvis. It may be that this haemorrhage is comparable to the bleeding which occurs after sudden decompression of the urinary tract, when the onrush of blood following the relief of pressure in the pelvis ruptures fine vessels in the kidney. Possibly so increased the engorgement of the kidney and led to haemorrhage. The kidney, having bled freely, seems to have had its function in abeyance for 48 hours, because no blood appeared in the urine at first. Perhaps renal secretion took some hours to become re-established and then the blood was washed down into the bladder. One of the writers (R. R.) has seen on two previous occasions profuse haemorrhage resulting from the too sudden decompression of a hydronephrosis.

The high blood-pressure in the patient following the injury is of interest, and this may be due either to the disturbance of the suprarenal glands (the rupture was in the neighbourhood of the suprarenal glands) or to suppression of renal function and the operation of a mechanism similar to that which occurs when the renal artery is partially obstructed with a clamp, as in the experiments of Goldblatt and others. Whatever the cause of this rise in pressure, it subsided gradually as the patient recovered, and only recurred during the operation when the suprarenal capsule was roughly handled during the course of dissection.

## ABNORMALITY OF THE CALCANEUS AS A CAUSE OF PAINFUL HEEL

### ITS DIAGNOSIS AND OPERATIVE TREATMENT

By A. FOWLER AND J. F. PHILIP

AMBULANCE ROYAL INFIRMARY

FREQUENTLY during the past few years we have observed at the Out-patient's Surgical Clinic a painful swelling on the posterior aspect of the heel immediately proximal to the insertion of the tendo Achillis. It was noted that the condition occurred in young women more frequently than among men, and as the upper margin of the back part of the shoe coincided with the site of the swelling, the cause was attributed to pressure. During cold weather repeated attacks of inflammation almost in the nature of a chilblain made walking a trial and proved a source of considerable irritation to the patient.

All such patients fell into one of two categories: (1) In the first group a definite bursa lying superficial to the tendo Achillis was excisable and thereafter no recurrence of the condition was seen; (2) In the second group no actual bursa was excisable, the thickened tissue superficial to the tendon appeared to consist of a chronic inflammatory reaction of the skin and subcutaneous tissues and a recrudescence of the syndrome was invariable.

Although the condition of retrocalcaneal bursitis has been discussed by several writers, we feel that too little attention has been paid to an underlying structural bone variation as the real cause of this condition. White (1913) gives an excellent survey of the symptomatology of retrocalcaneal bursitis and his views agree with those of Neilson (1921) in that they attribute the cause of the bursitis to trauma, such as may be caused by short shoes, excessive walking, etc. Both writers, moreover, believe that infection plays a part in its causation. Neilson stresses this point and states, "Bacterial infection is chiefly metastatic, the disease being on this account very often bilateral." We feel, however, that a bilateral condition is rather against a metastatic origin. White says, "Physiologically, it may be said that irregularities of the os calcis, more particularly those cases having a small spine posteriorly, have played a part, but the X-ray has demonstrated so many deviations in bone contours that this is almost a negligible factor." He thus advises removal of the bursa; nevertheless, he goes on to state: "It is not uncommon to find the superior posterior angle of the os calcis quite sharp, almost spinous in type, and it may be rounded off with an osteotome, though this is not at all necessary". Gottlieb (1928), writing on painful bursitis around the heel, points out that even though there is no exostosis shown on radiography, the results of irritation of

the periosteum and bone may be evidenced by erosion, osteophyte formation, and a thickening of the cortex.

As has been previously mentioned, patients falling into our second group were not relieved by excision of the thickened tissue superficial to the tendo Achillis and were in reality suffering from a true retrocalcaneal bursitis. We doubted very much if trauma due to excessive walking or short shoes was anything more than an aggravating factor in its causation and were still more dubious as to infection being the primary inciting agent, so that further search for a possible underlying cause in the os calcis itself was undertaken.

Lateral radiographs of the recurring cases show a somewhat peculiarly shaped os calcis, in that, immediately underlying the affected area, a prow-like projection is demonstrable. Its contour is smooth and *not* in the nature of an exostosis or ossification in the substance of the tendo Achillis, and we had doubts if this smooth bone could cause the trouble. Radiographs of the cases where a bursa was definitely demonstrable superficial to the tendo Achillis did not show this peculiarity. An investigation was therefore commenced into the variations of the os calcis from its anatomical standpoint.

In a series of 45 adult bones in the dry state, some of the measurements (all of which were made between fixed points) were fairly constant, differing in various bones by only a few millimetres. The most significant variation with regard to the subject under consideration occurs in the angle formed between the posterior and inferior surfaces of the os calcis. For measurements, see Fig. 429. These measurements, of course, may also be made from radiographs:—

A, The length of the bone as measured between the points shown averaged 75 to 80 mm.

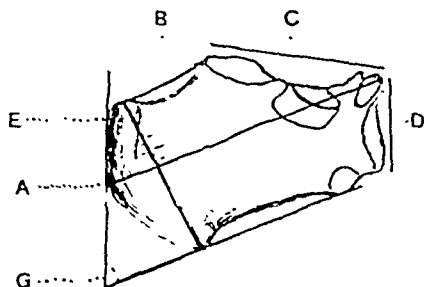
B, The distance between the posterior limit of the trochlear surface and the anterior limit of the bursal area averaged 20–30 mm.

C, The distance between the anterior extremity of B and the upper limit of the cuboidal surface varied between 45 mm. and 53 mm.

D, The height of the cuboidal articular surface was the most constant measurement, the average being 25–26 mm.

E, The distance between the apex of the bursal area and the greatest projection of the plantar surface of the internal tuberosity, when it is in the same horizontal plane as the external tuberosity, is roughly equal to half of A.

G, The size of the angle formed between the posterior surface and the plantar surface of the bone. It is found by producing the line drawn between the most prominent point of the bursal area and the greatest posterior projection of the internal tuberosity, to meet a line drawn between the most prominent point of the plantar surface below and medial to the cuboidal area and the greatest projection of the plantar surface of the internal tuberosity. In size, angle G was found to vary between  $44^\circ$  and  $69^\circ$ .



	A	B	C	D	E	G	
R	74	20	46	20	43	$62^\circ$	R
L	74.5	18.5	46	21	44	$67^\circ$	L
R	83.5	26	50	24.5	43.5	$63^\circ$	R
L	82	26	50	24.5	45.5	$68^\circ$	L
R	71	20	45	23.5	40.5	$63^\circ$	R
L	71	22	45	23	40.5	$63^\circ$	L
R	76	19	49	24	39.5	$66^\circ$	R
L	74.5	19	47.5	23	39	$66^\circ$	L

Fig. 429.—Diagram of os calcis and table of measurements.

Diminution in angle G is of little import. Yet in the cases showing structural changes in the soft tissues covering the bursal area, angle G is in the region of  $75^\circ$  or over, whereas the normal would appear to lie somewhere between  $44^\circ$  and  $69^\circ$ .

In the posterior part of the bone two variations from the usual occur, and at first glance their radiographs seem identical, yet one of them produces no symptoms, whilst the other, which is definitely abnormal, accompanies the condition described in the first section of this paper, e.g., the distance represented by the line B varies between 20 and 30 mm., its length having little effect on the size of angle G. Lessening of B in many cases merely signifies an anterior horizontal prolongation of the apex of the bursal area or a posterior horizontal prolongation of the trochlear surface, and not a true pathological projection of the bursal area; this type of bone produces a boat-shaped appearance of the superior surface of the posterior limb of the os calcis as shown in Fig. 430, A.

In this type, which is the non-pathological condition to which we refer, angle G is normal.

In the other type, which is pathological, we again find a boat-shaped appearance. This time, however, it is due to a true projection of the bursal area and is accompanied by an increase in angle G. So that a glance at angle G will differentiate the two conditions. In this second

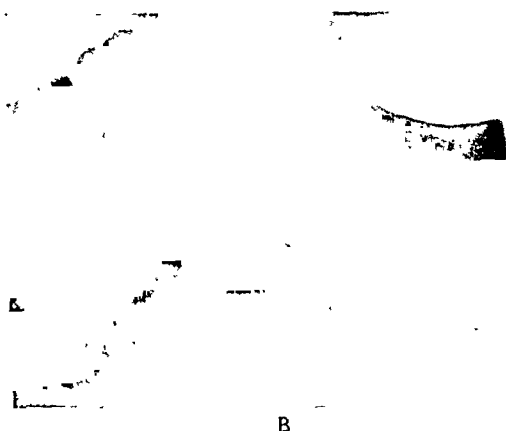
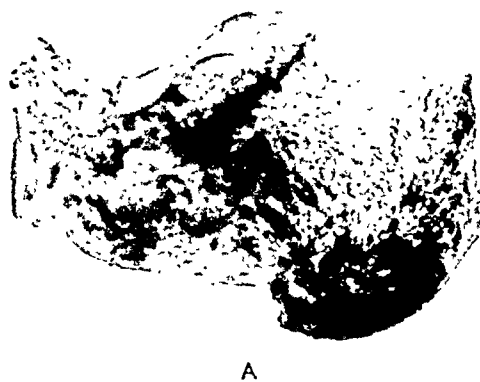


Fig. 430.—A, Boat-shaped appearance of the upper edge of the posterior limb of the bone, but with no increase in size of angle G. B, Boat-shaped appearance of the upper edge of the posterior limb of the bone, with increase in size of angle G.

type (Fig. 430, B) the increased projection of the bursal area which accounts for the increase in size of G comes at once to bear on the tendon above its insertion, as at this point the tendon cannot in any way be relieved from pressure. Secondary changes occur, therefore, in the bone, the tendon, and the overlying tissues.

The posterior surface of the os calcis is divisible into three areas (Fig. 431):—

1. A bursal area which is triangular with its apex directed upwards, and to which the tendon is not attached.

2. A rough quadrilateral area below the bursal area which gives insertion to the central part only of the tendo Achillis.

3. An inferior area which is triangular with its base directed upwards and which gives attachment to fascial structures continuous with the plantar fascia below and with the sheath of the tendo Achillis above.

Fig. 432 shows two interesting facts—namely, that the tendo Achillis has a two-fold attachment: (a) The central part of the tendon is inserted into the middle area on the posterior surface of the bone, while the lateral parts of the

area by the upper edge of the shoe causes the superficial inflammatory changes described.

Lowering the heel of the shoe increases dorsiflexion and does not help matters, while lowering the upper edge of the shoe, although it relieves external pressure over the affected area, does not affect the relation of the projection to the tendon.



FIG. 431.—Medial aspect of a sagittal section of the heel to demonstrate the relation of the bursa and tendon to the os calcis.



FIG. 432.—Lateral aspect of dissection shown in Fig. 431. Note the lateral expansion of the insertion of the tendo Achillis.

tendon sweep on to the medial and lateral surfaces of the os calcis, so that the central part of the tendon can be divided transversely, avoiding the lateral expansions, and when the central portion is re-sutured, there is little risk of permanently weakening the tendo Achillis. (b) The bursa between the tendo Achillis and the bone is small; the rest of the space between the tendon and the upper surface of the os calcis is filled by fat. The main part of the bursa is situated over the upper part of the bursal area, and only a small saccular prolongation intervenes between the lower part of this surface and the tendon just above its insertion.

As a result of these findings, it is obvious that minor degrees of projection of the bursal area come to bear almost at once on the tendon, and, further, that plantar flexion as would be supposed cannot materially relieve pressure at X (Fig. 431)—i.e., between the tendon and the bone—because the tendon is firmly strapped to the bone by the lateral expansions mentioned above. Dorsiflexion, however, will greatly increase the pressure at X, and this is easily demonstrable by radiographs taken in these positions, which show the soft tissues as well.

This increased backward projection of the bursal area occurs in the abnormally shaped os calcis and is accompanied by an increase in angle G. Fig. 430, B shows this well. The tenting of the tendon at this point, also due to the abnormal projection, is easily demonstrable, and the constant rubbing of the heel over this

With regard to those cases where no projection of the bone can be demonstrated radiologically, we found that simple excision of the adventitious bursa overlying the tendo Achillis insertion and modification of the shoes was followed by relief of symptoms, with no recurrence.

In view of these anatomical features it is obvious that without performing the simple removal of the redundant bone in the abnormal cases, a recurrence of the condition, as was our experience, is to be expected.

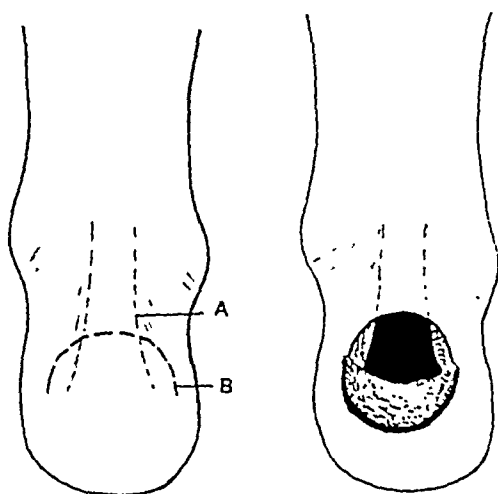
Most writers describe either a lateral or medial incision along the margin of the tendo Achillis as a method of approach to the retrocalcaneal bursa. As we consider removal of the projecting portion of bone an essential part of the treatment, and find it very difficult to obtain adequate access through either a lateral or medial approach, a central approach was designed, with partial division of the central part of the tendo Achillis immediately above its attachment to the bone. This exposure permits the even removal of the requisite amount of bone, including the bursa. Such an approach does not permanently weaken the tendon on account of its strong lateral attachments, previously described.

### OPERATIVE TECHNIQUE (Figs. 433-435)

1. A curved transverse incision is employed, with its convexity directed upwards and sufficiently

high to clear the pressure point of the edge of the shoe.

2. This flap is reflected downwards and any superficial adventitious bursa found deep to the skin is dissected out.



3. The skin over the tendo Achillis is undercut upwards to give further exposure of the tendon.

4. A vertical incision 5 cm. in length is next made through the tendo Achillis, extending down to a point about 1 cm. from its insertion. From the lower end of this incision two downward and outward extensions, each about 1.5 cm. long, are made in the central portion of the tendon.

7. The tendo Achillis is closed with a few catgut stitches and the skin-flap sutured back in the ordinary manner.

8. The foot and ankle are put up in a position of plantar flexion in plaster-of-Paris for three weeks,

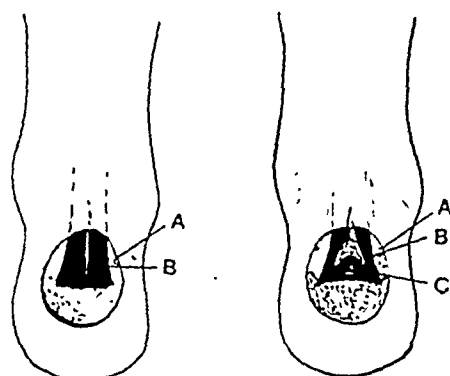


FIG. 433.—Diagrammatic representations of the operation devised for the radical cure of retro-calcaneal bursitis.

and the plaster should be strong enough to allow some weight-bearing in the front part of the foot.

9. At the end of three weeks, active exercises are begun and the heel of the shoe is raised about  $\frac{1}{2}$  in. and thereafter gradually lowered to normal in the course of the next fortnight.

At the end of six weeks the patient is able to get about normally.

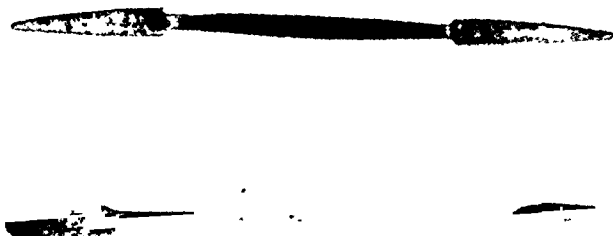


FIG. 434.—Dental riffler.

At this point the incision through the tendon is shaped like an inverted Y.

5. On retracting the incision in the tendon, an adequate exposure is now obtained, through which the bursa is removed. The prominent area of bone is easily and evenly removed in its whole width, and it is important to remove any large lateral projections.

6. The raw area on the bone is carefully smoothed off by means of a dental riffler (an instrument which we find most useful for operations on small bones, especially in confined spaces) (Fig. 434).



FIG. 435.—Radiograph of os calcis following operation.

In order to illustrate the two types, we append radiographs of each type:—

Case 1 shows abnormal angle G ( $84^\circ$ ) with marked projection of the bursal area of the os calcis (Fig. 436). This patient was operated upon by the method described and has obtained relief of symptoms.

Case 2 illustrates the type where the os calcis appears to be normal, angle G being  $64^\circ$ . There is, however, a definite adventitious bursa superficial to the tendo Achillis and easily seen on the X-ray film and in the photographs (Fig. 437).



# SUMMARY

1. The cause and treatment of a very common and crippling condition of the heel is discussed.

2. Anatomical variations in the os calcis are shown to be considerable in such cases.  
3. Reference is made to the importance of the increase in the posterior projection of the os calcis as being an important causative factor of retrocalcaneal bursitis.



A



B

FIG. 436—Case 1. A, Photograph of heels showing enlarged bursa. B, Radiograph showing the abnormal os calcis.



A



C

FIG. 437—Case 2. A, Photograph of heels with bursa due to an unsuitable type of footwear. B, Normal os calcis. C, Cause of bursitis, unsuitable footwear.

4. Operative treatment is described, with a simple method of approach for the adequate and even removal of the abnormal projection of the os calcis.

## REFERENCES

- WHITE, C. S. (1913), *New York med. J.*, **98**, 263-265.  
NEILSON, A. L. (1921), *J. Amer. med. Ass.*, **77**, 463.  
GOTTLIEB, A. (1928), *Amer. J. Physiol. Therapy*, **5**, 347.

## INGUINAL HERNIA

## A NEW OPERATION WITH SPECIAL APPLICATION TO THE SERVICES

BY SURGEON COMMANDER W. V. BEACH, R.N.

THE problem of the certain operative cure of inguinal hernia in young men still remains a challenge to the surgeon. Despite numerous varieties of operative technique, we still read of a surprisingly high rate of recurrence in the published figures. The great diversity of method indeed indicates surgical dissatisfaction with results.

Among the many causes blamed for recurrence after the classical 'repairs', is the failure of the muscular portion of the internal oblique to adhere firmly to the inguinal ligament after suture to it.

margin of the rectus sheath and extends upwards to the same level as the first. This incision must open at its beginning into the external inguinal ring. The two are now joined by a transverse incision (Fig. 438). This aponeurotic flap is freed from the deeper layer and reflected downwards; the only mild difficulty is in the separation of the flap at the margin of the rectus sheath. Thus the inguinal canal is opened from above, and the hernial sac is isolated from the cord and is excised in the usual way (Fig. 439). The

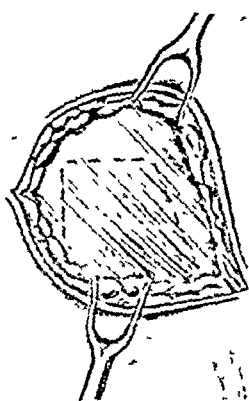


FIG. 438.—Showing the three incisions (see text).

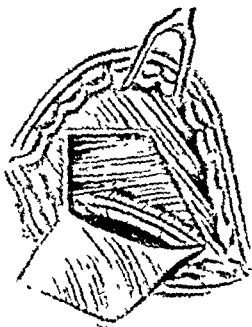


FIG. 439.—The aponeurotic flap reflected downwards.

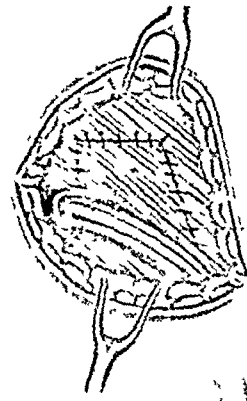


FIG. 440.—The flap, passed under the cord, and sutured in its original position.

Hence the variety of methods of circumventing this—fascial grafts, non-absorbable materials, suture of the external oblique behind the cord (Wyllis Andrews)—all depending on the holding of sutures placed at vital points of stress. A method is described here by which all repair of the posterior wall of the inguinal canal is completely avoided and the canal itself suppressed.

## TECHNIQUE

The skin incision is made in the line of the inguinal canal and extends from 1 in. lateral to the internal inguinal ring well down over the pubic tubercle; it is then deepened to expose the external oblique, and the upper margin of the wound is retracted so as to enable the external oblique to be cleared for 3 in. in an upward direction. Two points are carefully defined: (1) the point on the external oblique immediately superficial to the deep inguinal ring; and (2) the pubic tubercle with the insertion of the inguinal ligament. From just lateral to the deep ring a vertical incision 2 in. long is carried upwards through the aponeurosis of the external oblique. From the pubic spine another incision divides the external oblique just mesial to the

stump is anchored well up behind the upper margin of the internal ring.

The reflected flap of the external oblique is now passed under the cord, pulled up, and sutured into its previous position (Fig. 440).

Finally a stitch is placed beneath the cord at the lower end of the lateral vertical incision to prevent any possible splitting of the external oblique, and the cord is thoroughly freed over the pubic spine to obviate any tension. When this has been completed the following facts become evident:—

1. The inguinal canal has ceased to exist and is replaced by an 'inguinal exit', the outer layer of which is not strong unyielding aponeurosis, which can be adjusted in size to a nicety by the suturing of the vertical incision.

2. This exit has been placed lateral and above the centre of the internal inguinal ring, thus putting a further gravitational obstacle in the way of a recurrence.

3. The external inguinal ring is now obliterated.

4. All tissues sutured are 'like-to-like', thus obviating the doubtful union of muscle, sometimes under tension, to ligament.

5. No suture is required to bear any strain whatever, except possibly at the area of the obliterated external ring where the armed needle bites well into the periosteum of the pubic tubercle, and where the reflected inguinal ligament and the inguinal aponeurotic falx already lend support.

6. Any plugging action of the cremaster, if this really exists, is in no way impaired; in fact there is now a really strong ring which this muscle may plug.

7. A sound external oblique is essential for the success of the operation. It is thus the ideal operation for fit young men in the services.

Though the step is unnecessary, tradition can be preserved by the additional step of "repairing" the posterior wall in the classical manner.

The method was first used four years ago, and has since been employed in over three hundred cases, consequently no impressive figures of lengthy cures can yet be given. The immediate and recent results are excellent, and up to date no recurrence has been seen or reported. This preliminary report is therefore intended as an inducement to others to give the method a wider trial.

## ULCER OF THE SECOND PART OF THE DUODENUM

By P. T. CRYMBLE

QUIN'S UNIVERSITY, BELFAST

ULCER of the second part of the duodenum receives very little attention in our text-books and is merely suggested by the statement that "ulcer usually affects the first part of the duodenum". I have been engaged in abdominal surgery for the past thirty-four years and all my 4 cases of a palpable lump in the suprapapillary portion of the second part of the duodenum

section through the upper half of the second part of the duodenum, he will see how deeply placed and inaccessible the structure lies. It lies retroperitoneal, postero-lateral to the head of the pancreas, and behind the gall-bladder. It also lies in front of the hilum of the right kidney. In spite of its deep position a fibrotic lump can be palpated without any dissection. In my

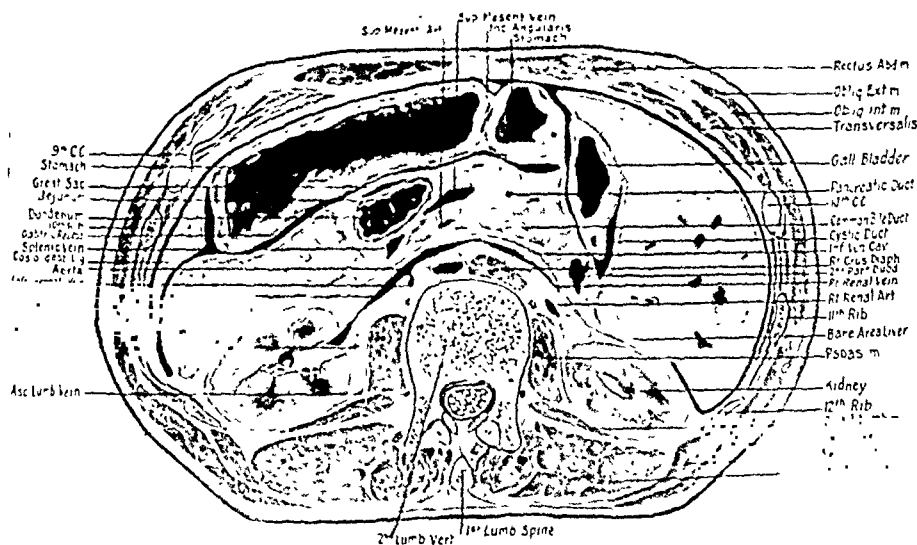


FIG. 441.—Section showing the relative position of the second part of the duodenum.

have been recognized in the past five years. One suspects that other cases have been missed and that perhaps radiographers, physicians, and surgeons are not fully alive to the possibility. The lesson which I have learned recently is that *when a patient has duodenal symptoms but shows a normal first part of duodenum on X-ray examination and on surgical exploration, do not neglect to palpate the second part of the duodenum.*

If the reader will refer to the section reproduced in this article (Fig. 441), a horizontal

cases the lump was of walnut size and all the cases responded well to a posterior gastro-enterostomy.

### CASE REPORTS

*Case 1.*—McNally, male aged 23. February, 1939. Duodenal ulcer producing an hour-glass contraction at the junction of the first and second parts of the duodenum (Fig. 442).

*HISTORY.*—For eight years he has complained of epigastric pain coming on half an hour after food. The pain wakens him regularly at 1 a.m. and is

relieved by food and alkalis. The appetite is good, but he is afraid to eat. Occasional vomiting.

**X-ray Examination.**—Hour-glass contraction with a small medially placed diverticulum of the second part of the duodenum.

**AT OPERATION.**—Visible and palpable scar on the anterior wall of the first part of the duodenum.

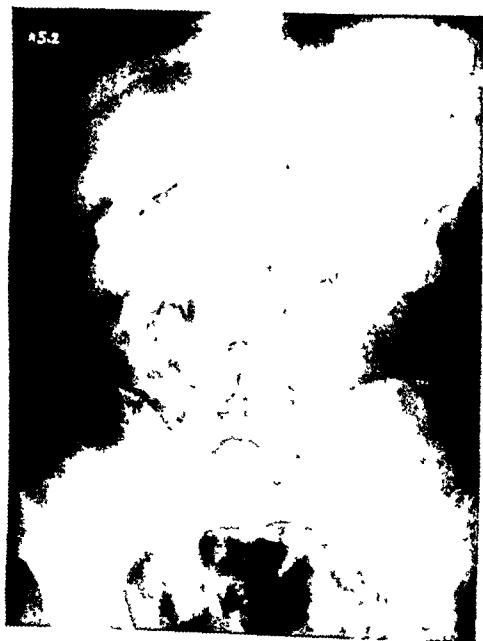


FIG. 442.—Case 1. Radiograph of an opaque meal of the stomach and duodenum, showing an hour-glass contraction of the duodenum with a niche on the medial border.

Palpable lump in the wall of the second part of the duodenum near its upper end and corresponding to the hour-glass contraction seen in the radiograph. Posterior gastro-enterostomy. Result—very good.

**Comment.**—The diagnosis of this case was easy and was made in the X-ray room. At operation one learned the situation and feel of the ulcer. By this experience one was enabled to diagnose the remaining three cases, all of which were obscure.

**Case 2.**—W. McC., a man aged 67.

**HISTORY.**—The dyspeptic symptoms began in January, 1940, and took the form of epigastric pain two hours after food or when hungry. The pain was relieved by alkalis or by food.

In May intermittent vomiting appeared, and black stools were passed on two occasions. The vomit at times was dark brown. An opaque meal carried out on July 2 showed a hyperperistaltic but otherwise normal stomach, and a complete absence of any duodenal shadow (Fig. 443).

On July 12 the abdomen was opened through a right paramedian incision, with the centre of the incision opposite the umbilicus. No gastric or duodenal ulcer was found; a rudimentary appendix was removed.

On Aug. 2 he had acute retention and required the passage of a catheter.

Subsequent to this operation he received treatment for anaesthesia and loss of power in the legs. The condition was diagnosed as peripheral neuritis, and he was given injections of vitamin B<sub>1</sub>.

On Dec. 8, 1941, he was admitted to the medical wards with a recent history of haematemesis and a long history of epigastric pain, vomiting, and loss of weight.

A few days after admission there was sudden weakness and palpitation, and he vomited two pints of dark blood. The haemoglobin on Jan. 5, 1942, was 50 per cent.

Opaque meal at this time again showed a normal stomach, but no duodenal shadow. The hyperperistalsis noted in July, 1940, was no longer present.

On May 23, 1942, he was admitted from the surgical out-patient department, owing to marked dilatation of the stomach and gastric retention.

**ON EXAMINATION.**—

**Stomach.**—Visible peristalsis. Marked enlargement of the gastric air-bubble on percussion. Opaque meal X-ray examination showed a dilated stomach with retention (Fig. 444).

**Prostate.**—Enlarged. Residual urine, 8 oz.

He gave a history of epigastric pain, vomiting, and loss of weight since January, 1940.

The blood-urea was 60 per cent.

**AT OPERATION.**—After one week of gastric lavage, an operation was performed through a high right paramedian incision, and the following pathology



FIG. 443.—Case 2. July 2, 1940. Opaque meal prone. First meal outlines the colon; second meal outlines the stomach. Duodenum not seen.

disclosed: Stomach very large. Palpable thickening in the anterior wall of the upper part of the pars descendens duodeni. The gastrocolic ligament was adherent to the ulcer area.

A posterior gastro-enterostomy was performed, and convalescence was uneventful.

It now remains to be seen if the operation will permanently relieve the patient of the epigastric pain, vomiting, and loss of weight. He still has his enlarged prostate with a nocturnal frequency of 1, but no other urinary symptoms.

**Comment.**—In this case we have been able to follow the progress of a duodenal ulcer through

the stages of pain, hæmorrhage, and obstruction. The radiographs are interesting, since in July, 1940, and in January, 1942, they show merely an absence of duodenal filling, whilst in May, 1942, they show marked enlargement of the stomach and a gastric retention.

The operation in July, 1940, failed to disclose any duodenal ulcer, but the low position of the incision and the inaccessible pars descendens duodeni would place difficulties in the way of early recognition.

Ulcer of the second part of the duodenum is not uncommon. It may be the only lesion, or it may accompany ulcer of the first part of the



FIG. 444.—Case 2. May 20, 1942. Appearance six hours after a meal. Stomach much enlarged and some retention.

duodenum. Its recognition is not easy, since in the early stages, owing to its attachment to the pancreas, one may be uncertain as to whether a suspected thickening is an ulcer or pancreas. Inspection of the peritoneal surface of the duodenum may in some cases show puckering.

#### Case 3.—Mr. T.

**HISTORY.**—This man arrived in hospital in March, 1944, with a cæcostomy tube draining some fluid fæces, some fæces passing per rectum, and carrying out a daily gastric lavage.

The abdomen was somewhat distended and there was a considerable amount of splashing. We were in doubt as to whether the distension was colonic or gastric or a mixture of the two.

There was a history of dysentery many years ago which was followed by dyspepsia, and in October, 1943, he developed signs of intestinal obstruction for which a cæcostomy was performed.

An opaque enema revealed no obstruction of the colon and an opaque meal showed a very large pto-

stomach with a complete six-hour gastric retention.

**AT OPERATION.**—The transverse colon was much elongated, dilated, and blue in colour. It ballooned out of the wound and was replaced with difficulty. The stomach was large, atonic, and showed no obstruction at the pylorus. There was a hard lump in the second part of the duodenum about the size of a walnut.

Posterior gastro-enterostomy was performed and the cæcostomy tube removed.

**PROGRESS.**—He made an excellent and rapid recovery. The cæcostomy closed naturally and he left hospital in three weeks. A recent report from him states that he is perfectly well and has put on 1½ st. in weight.

**Comment.**—This is a case of double pathology in which we have the combination of dilatation of the transverse colon and a duodenal ulcer. The history suggests that the course of events was dysentery—deformed colon—duodenal ulcer—gastric retention. As my fourth case had a somewhat similar dilated blue colon, it may be that such a colon leads to duodenal ulcer.

#### Case 4.—N. McW., a joiner aged 46.

**HISTORY.**—Recurrent attacks of epigastric pain for the last thirteen years. Appendicectomy in 1913.

In 1931 the patient was in a medical ward of the Royal Hospital for treatment of stomach trouble.

In 1938 he was X-rayed and examined in the surgical out-patient department of the Royal Hospital and no operation advised.

In 1943 he was X-rayed and examined in the surgical out-patient department of the Royal Hospital. He was found to have hyperchlorhydria and no operation was advised.

**ON EXAMINATION.**—A thin worried-looking man, complaining of constipation, epigastric pain relieved by alkalis, and recently vomiting. Stomach splashing.

**X-ray Examination.**—Stomach normal. No filling of the duodenum.

**AT OPERATION.**—Transverse colon blue and dilated. Stomach somewhat larger than normal. Palpable lump in the upper half of the second part of the duodenum. A posterior gastro-enterostomy was performed.

**PROGRESS.**—Normal convalescence. Left hospital sixteen days after operation.

## DISCUSSION

Whilst Case 2 shows that ulcer of the second part of the duodenum may be missed at operation, Case 4 illustrates the difficulties which the X-ray department may encounter. In Case 3 there was marked obstruction leading to a complete six-hour retention in the stomach. In Case 4 there was no gastric retention in spite of the fact that there was a palpable lump at operation. Only in Case 1 was the condition diagnosed by the radiographer by the hour-glass contraction at the site of the ulcer.

For many years one was accustomed in suspected duodenal ulcer to limit the examination to the first part, but it is now clear to me that it is also necessary to palpate that deeply situated upper half of the second part of the duodenum. Only the palpable ulcer can be recognized, but this is the one which is suitable for operation.

## A CASE OF PSEUDARTHROSIS FOLLOWING FRACTURES OF THE LUMBAR TRANSVERSE PROCESSES

By GEOFFREY HYMAN

L.M.S. ORTHOPEDIC SURGEON

NEW-BONE formation in muscle following injury is not common in the lumbar region. The case to be described was associated with fractures of the lumbar transverse processes and the new bone produced a well-formed pseudarthrosis. I was unable to find a similar lesion reported in the literature and there are interesting points in the diagnosis and pathology of the condition.

### CASE REPORT

**HISTORY.**—A miner, aged 34 years, was referred to the out-patients' department at Pinderfields Emergency Hospital from another hospital on March 3, 1943. In December, 1941, he was hit on the back by a fall

lumbar spine showed moderate rigidity, with pain on forward flexion and lateral flexion to the right. Rotation to the right was also limited and painful. There was deep tenderness on pressure on the right side of the lumbar vertebrae at the level of the 2nd and 3rd spinous processes. The radiograph showed bony processes projecting from the adjacent borders of the transverse processes of the 2nd and 3rd lumbar vertebrae on the right side; a well-marked joint had formed between the new bony masses (*Fig. 445*). The question of a congenital abnormality was raised, and it was not until the radiographs taken immediately after injury became available that an acquired pathology was definitely proved (*Fig. 446*). They showed fractured right transverse processes of the 2nd, 3rd,



FIG. 445.—Radiograph showing well-developed pseudarthrosis.

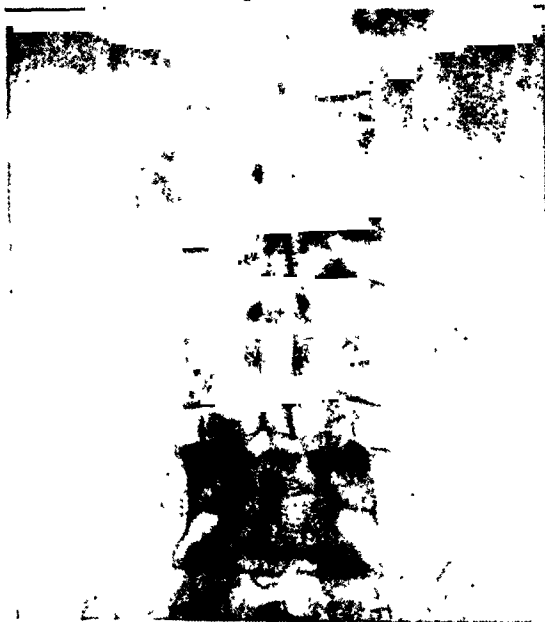


FIG. 446.—Radiograph showing fractures of the right 2nd, 3rd, 4th, and 5th transverse processes.

of roof whilst working at the coal face. He sustained fractures of the right transverse processes of the 2nd, 3rd, 4th, and 5th lumbar vertebrae. He was treated as an out-patient and was not confined to bed. The lumbar region was strapped with elastoplast for 12 weeks and afterwards he had massage for several weeks. Two months after injury he developed incontinence of urine, and this lasted two months. He returned to work in March, 1942, but could not manage his old job at the coal face. He was employed in much lighter work as an engine driver.

He complained of constant pain in the lower part of the back. The pain was worse on bending and he could not continue his work because of it.

**ON EXAMINATION.**—He was a thin, nervous, poorly-developed patient with a bad posture. The

4th, and 5th lumbar vertebrae with wide separation of the 3rd process. Further radiographs taken in the course of a renal investigation in June, 1942, showed that at that time a pseudarthrosis had partially formed between the affected vertebrae (*Fig. 447*).

**TREATMENT.**—It was thought doubtful whether the patient's symptoms were altogether organic in origin and non-operative measures were tried first. On March 9, 1943, manipulation of the spine was carried out under anaesthesia. A good range of movement was obtained and adhesions were broken in extension of the lumbar spine. There was no improvement following manipulation, and on March 19 10 c.c. of 1 per cent novocain were injected into the tender area between the 2nd and 3rd lumbar vertebrae on the right side. There was immediate

relief, but this was only temporary and the pain recurred four days later. As a last resort excision of the new joint was undertaken, although the prognosis was not thought to be good.

**Operation (April 4).**—Trilene anaesthesia. A mid-line incision 5 in. long was made, centred on the 2nd and 3rd lumbar transverse processes previously identified by skin marking and a special radiograph. The right erector spinæ was retracted outwards and

previous radiograph. He was still working when he last attended on July 20, and stated that he felt very well and had only occasional backache. Spinal movement was almost full.

## DISCUSSION

It will be seen that a well-developed joint had formed between two pieces of adventitious bone

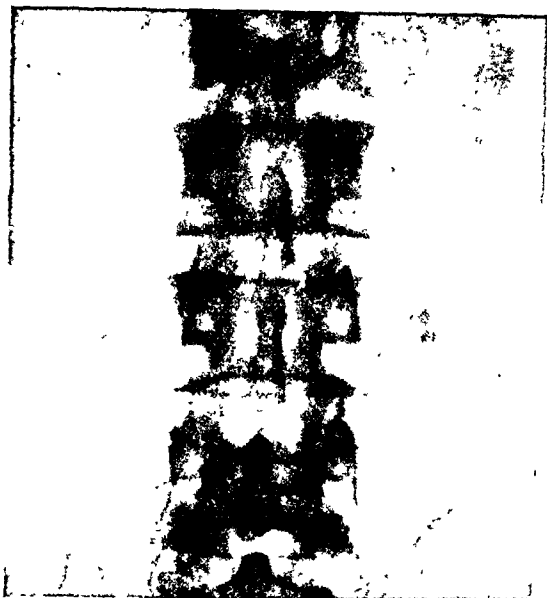


FIG. 447.—Radiograph taken in course of renal investigation, showing partial formation of pseudarthrosis.



FIG. 448.—Radiograph taken four months after operation shows no evidence of further new bone formation.

the transverse processes of the 2nd and 3rd lumbar vertebrae were exposed. A rounded bony bar projected downwards from the lower border of the 2nd lumbar transverse process and met a similar upward projection from the 3rd transverse process, forming a joint enclosed by a capsule. The new bone appeared to lie in the plane between the erector spinæ and the psoas, although it was not possible to be certain as the whole structure was closely adherent to the surrounding muscle. Appreciable movement at the new joint could be seen on lateral flexion of the spine. The mass of new bone together with the joint was removed in one piece by dividing the attachments to the transverse processes with a  $\frac{1}{2}$ -in. osteotome. The wound was closed in layers. The post-operative course was uneventful. He was allowed to sit up in bed four weeks after operation and active exercises were gradually begun. He was walking a week later.

**SUBSEQUENT PROGRESS.**—His backache cleared up rapidly and by May 31 he had nearly full spinal movement, with only slight pain on lateral flexion. On June 28 he had no backache, but complained of stiff, painful feet, and he was kept in hospital for treatment of this condition. He was discharged to a convalescent home on July 12, but was readmitted on Aug. 23 complaining of a recurrence of pain, but to a less degree. A radiograph taken at that time showed no evidence of new-bone formation following operation (Fig. 448). On Oct. 18 he started work in the lamp room, doing five shifts a week. Subsequently he maintained his improvement, and a radiograph taken on Feb. 4, 1944, showed no change from the

which showed no histological abnormality (Fig. 449). There was a fibrous capsule, but no evidence of a synovial membrane. The most interesting features were, first, the presence of a band of fibrous tissue between the bone masses preventing their union and resulting in a pseudarthrosis, and secondly, the comparatively well-organized hyaline cartilage covering the joint surfaces (Fig. 450).

It is likely that in the case described there must have been extensive muscle damage at the time of injury and that small fragments of bone were detached from the fractured surfaces into the torn muscle which formed a suitable nidus for new-bone formation. R. Watson-Jones (1940) has pointed out that cases of multiple fractures of the lumbar transverse processes are usually accompanied by extensive damage to the surrounding soft tissues and says that these cases should be treated as severe injuries. He recommends several weeks' immobilization of the lumbar spine in plaster-of-Paris. It is possible that in the case discussed lack of adequate immobilization predisposed to new-bone formation (Grieg, 1931), but we have always treated apparently similar lesions by early movement without ill effect. Also I have described a case of extensive new-bone formation in the region of the elbow following

injury, although prolonged immobilization had been carried out from the earliest stage (G. Hyman, 1942). It is interesting to note that there was not the slightest tendency for further new bone to form following operation in spite

## SUMMARY

1. A case of new-bone formation associated with pseudarthrosis is described following fractures of the lumbar transverse processes.

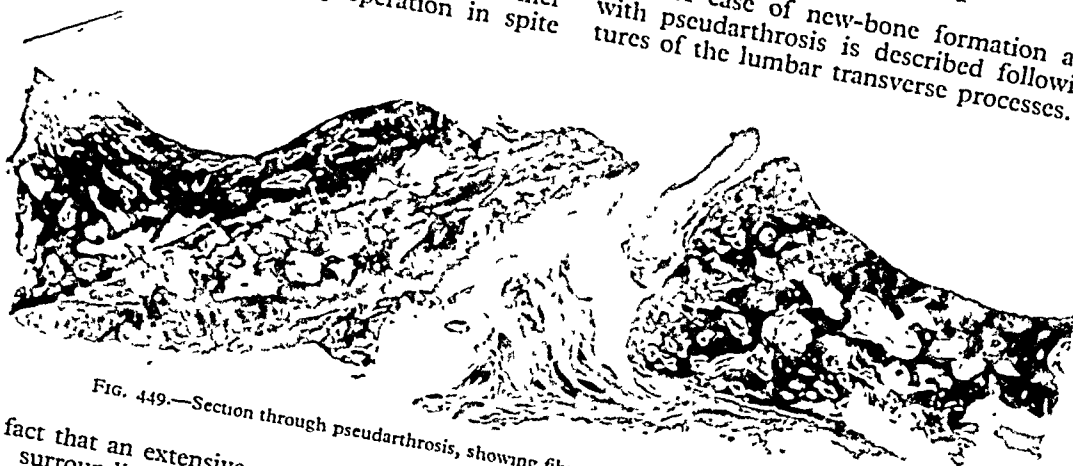


FIG. 449.—Section through pseudarthrosis, showing fibrous band between joint surfaces. ( $\times 5$ .)

of the fact that an extensive exposure of the soft tissues surrounding the damaged bone was required. Apart from four weeks' rest in bed after operation no special fixation of the spine seemed to be necessary.

2. The pathology and differential diagnosis of the condition are discussed.

**Radiology.**—The radiograph showing the well-formed joint (Fig. 445) was seen by two radiologists, who both considered it was a congenital abnormality in spite of the previous history of fractured transverse processes. At the time they did not have the opportunity of seeing the radiograph taken at the time of injury (Fig. 46) as it was not then available. One stated: "Congenital malformation of transverse process of L.2 and 3 on the right side. The processes are much wider than those of the opposite side and there is a false joint between them. (Major Peter Kerley.) The other said that he had occasionally seen similar radiographs before and was strongly of the opinion that the condition was congenital. (Dr. Wilkie.)"

In view of the above reports it is worth considering the radiological diagnosis of the lesion if the original radiographs had not been accessible. No acquired lesion in this site appears to have been described. Also in favour of a congenital pathology is the well-formed joint histologically showing hyaline articular cartilage. Against a congenital lesion is the fact that the site of the new joint is higher than is usual for such abnormalities in the lower spine, the common position being at the lumbo-sacral junction. If this had been a congenital lesion it might have been expected that a secondary scoliosis would have developed during the period of spinal growth. It seems possible that similar lesions diagnosed as congenital may really be acquired, as it is not unusual for fairly severe back strains to be treated without radiological examination and therefore fractured transverse processes may be missed.

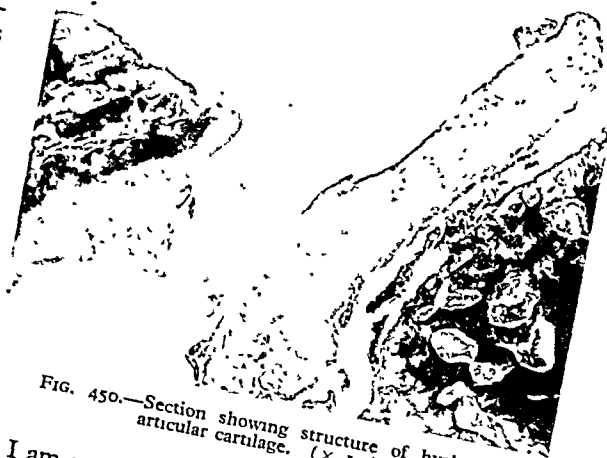


FIG. 450.—Section showing structure of hyaline articular cartilage. ( $\times 15$ .)

I am grateful to Dr. Freida Young for help in the pathology of the case, and to Mr. Manby, of Leeds University, for preparing the microphotographs. I also thank Dr. Robson, of Pontefract Infirmary, for the loan of the early radiographs and Dr. J. Thomas, Superintendent of Pinderfields Emergency Hospital, for permission to publish the case.

## REFERENCES

- GRIEG (1931), *Surgical Pathology of Bone*, 170. Edinburgh.
- HYMAN, GEOFFREY (1942), "Ossification about the Elbow," *Brit. Orthop. Ass. meeting*, Oxford, Jan.
- WATSON-JONES, R. (1940), *Fractures and other Bone and Joint Injuries*, 197. Edinburgh.



## ACTINOMYCOSIS FROM PUNCH INJURIES

### WITH A REPORT OF A CASE AFFECTING A METACARPAL BONE

By H. JACKSON BURROWS

SURGEON COMMANDER, R.N.V.R.  
ASSISTANT ORTHOPAEDIC SURGEON, ST. BARTHOLOMEW'S HOSPITAL

No reported case of actinomycosis of a metacarpal bone is known to the writer, but there have been at least two previous cases of actinomycosis of the hand seemingly produced by cutting this on an adversary's tooth in fighting. From both viewpoints the following case is of interest.

#### CASE REPORT

The patient, of Southern Irish extraction, was an Able Seaman aged 26, who had joined the Royal Navy eight years before; previously he had been a shipyard labourer and had always dwelt in Liverpool. Ten weeks before his admission to an orthopaedic

72 hours. He had then an almost dry sinus on the back of the fourth metacarpal head.

Radiographs (Surg. Lieut. I. E. Fergusson R.N.V.R.) sent with him showed rarefaction of the medial half of this and a cuff of subperiosteal bone covering the distal two-thirds of the shaft. These changes were also seen in radiographs taken on admission (Surg. Lt.-Cmdr. T. Fitzpatrick, R.N. (Fig. 451).

Twelve days later the palm over the fourth metacarpal shaft became swollen, red, and hot; and



FIG. 451.—Radiographic appearance of the fourth metacarpal bone, 72 days after injury to the fist.

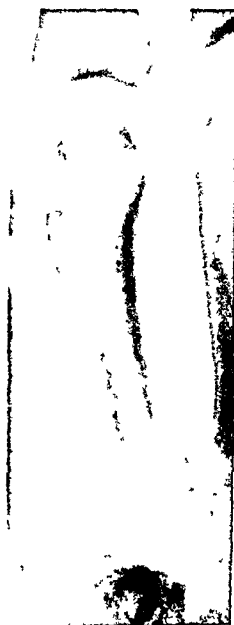


FIG. 452.—Appearance 72 days later than Fig. 451 and after 34 days of iodide treatment.



FIG. 453.—Appearance 43 days later than Fig. 452 and after 77 days of iodide treatment.

unit he assaulted one of his fellows and broke one of this man's teeth, which were said to be in indifferent condition. The stump caused a clean-cut wound over the fourth right metacarpal head, extending down to and marking the extensor tendon but not dividing it. The wound was bathed in 1-1000 acriflavine, dried, packed with sulphanilamide, and partially closed with one loose horsehair stitch. Next day the wound was slightly inflamed; the stitch was removed, the wound was repacked with sulphanilamide, the fingers were immobilized, and sulphapyridine was given by mouth (1 g. t.d.s. only). The condition improved rapidly; by the sixteenth day recovery appeared complete, except for slight swelling of the knuckle, and the patient returned to duty. About five days later the wound broke down again and discharged for nine days. Thereafter a fluctuating swelling was twice incised, with release of pus and subsequent healing. He was sent from his ship to a Naval orthopaedic centre by hospital carrier, in which he received 18 g. of sulphathiazole during

nine days later still, an abscess pointed at the distal palmar crease, where it was opened, the released pus containing pale yellow granules. The cavity led to the ulnar side of the fourth metacarpal, but no bare bone was felt. Sulphanilamide and tulle gras were applied. The granules were found to consist of the mycelium of actinomycosis (Surg. Cmdr. Miller, R.N.). The wound healed in about seven days, only to break down again and require further drainage 24 days after the first. He had already started a course of potassium iodide five days before (30 gr. daily for 5 days, 60 gr. daily for 9 days, and 80 gr. daily thereafter). Radiographs (Surg. Lt.-Cmdr. T. Fitzpatrick, R.N.) taken 72 days after the first, and after 34 days of iodide treatment (gr. 2760), showed less rarefaction in the head and a much more nearly normal bony outline (Fig. 452). The potassium

# ACTINOMYCOSIS FROM PUNCH INJURIES

50

iodide was discontinued after a total dosage of 4800 gr. (311 g.) during 51 days. A radiograph taken 115 days after the first showed the fourth metacarpal bone looking almost normal, but still with very slight thickening (Fig. 453). Clinically the condition had subsided entirely, leaving very slight palpable thickening of the metacarpal neck. There was full function of the hand.

A follow-up report (Surg. Captain R. W. Higgins, O.B.E., R.N.) of an examination made 260 days later, and 332 days from the original injury, indicated that the clinical condition had remained satisfactory. A radiograph was practically normal, except for a persistent rarefied area in the fourth metacarpal head (Fig. 454).

## DISCUSSION

**Previous Cases of Actinomycosis from Punch Injuries.**—In 1915 Cope reported a case of actinomycosis of the hand in a man of 27 who had knocked out some of an opponent's front teeth with a blow three months before. A small wound on the back of the right hand was caused. Two days later this was followed



FIG. 454.—Appearance 145 days later than Fig. 453, 260 days after Fig. 451, and 332 days from the original injury.

by acute inflammation, which soon subsided, leaving an area of indolent inflammation involving the first intermetacarpal space. Pus was released from time to time, as witness numerous healed scars and a discharging sinus. Actinomyces was found in the pus. With vaccine treatment the wound healed within a month, and remained so over a follow-up period of 10 months. No radiographic examination was recorded.

In 1917 McWilliams described the case of a man aged 20 with actinomycosis of the proximal phalanx of the left middle finger which had been cut on an adversary's tooth six months before. The cut had healed in four days, but slowly diminishing function and increasing swelling of the finger occurred. About five months later the finger became painful, the scar broke down, discharged a few drops of pus, and then closed again in three days. A fusiform, tense, brawny,

slightly tender swelling was found attached to the deep structures on either side of the phalanx. A frozen section was thought to show sarcoma, and the finger was amputated at the metacarpophalangeal joint. No involvement of the tendons and their sheaths was found, and the swelling had limited the range of movement only by its size and position. The phalanx showed sclerosis and cortical thickening, with erosion of medial and lateral aspects, but no sign of the fungus in the bone. Sections of the overlying soft tissues, however, revealed multiple abscesses, in one of which—away from the bone—the ray fungus was found.

**Clinical Features of the Three Cases of Punch Actinomycosis.**—These patients were all men in the third decade who cut the skin of the fist on an adversary's tooth. Some transitory acute inflammation occurred in two, but the skin healed within a few days in at least two of the cases, only to break down again afterwards, so that there was or had been a sinus in all cases by the time they were diagnosed, between ten weeks and six months after the injury. The signs were those of chronic subcutaneous infection with suppuration and sinus formation. In the two cases X-rayed the changes were those of a small cavity in the affected bone and irregular subperiosteal thickening. In the same cases the Wassermann reaction was negative. The diagnosis was made from examination of the pus in two cases, but in a third it was made by section after amputation of the affected finger, which had been thought to be sarcomatous. In this connection it is useful to remember that sarcomata of the bones of the hand, as of the foot, are very rare. There should be no difficulty in diagnosing osteitis, and examination of the pus from a sinus as a matter of routine should reveal the fungus.

**Source of Infection.**—It is known that actinomyces of, or resembling, pathogenic types inhabit the mouths of seemingly healthy persons, and the presumption is strong that these patients acquired their infection by implantation of the fungus from the adversary's tooth into the wound which it made. Through the kindness of Surg. Lt.-Cmdr. Lavender, R.N.V.R., and Capt. W. H. J. Baker, R.A.M.C., search of the mouth of our patient's adversary was carried out six months later, but without discovering actinomycosis.

**Mode of Infection of the Bone.**—Cope (1938) summarized the methods of infection of bone by actinomyces as: (a) Primary; (b) Spread from a neighbouring focus; and (c) Metastatic. He quoted McWilliams's case as a very unusual example of the first, though the histology suggested the second method—spread from a neighbouring focus. In our case it was specifically stated that the wound did not traverse the extensor tendon, and so here too there is evidence to suggest that primary implantation occurred into the soft tissues, whence the bone was invaded secondarily. In Cope's case we do not know whether the bone shared in the soft tissue affection.

# THE BRITISH JOURNAL OF SURGERY

## SUMMARY

1. A case of actinomycosis affecting a metacarpal bone is described.
2. This followed a punch injury, the skin being cut by the opponent's tooth.
3. Two other cases of actinomycosis of the hand similarly acquired have been found in the literature.
4. The clinical features are discussed.
5. It is probable that, in each case, the actinomyces was inoculated from the tooth at the time of the injury.
6. In two of the three cases bone was involved. There is some evidence to suggest that inoculation took place into the soft tissues and that the bone was secondarily affected. It is unknown whether or not the bone escaped in the remaining case, because radiography is not recorded.
7. There exists a small group of cases which may conveniently be termed 'punch actinomycosis', on an analogy with the term 'punch fracture.'

So far as they could be identified, the geographically dispersed collaborators in this case have been acknowledged in the text, except Surg. Lieut. D. G. Huntly, R.N.V.R., from whose case notes of the earlier stage I have drawn extensively. My thanks are due also to the Medical Director-General of the Navy, Sir Sheldon F. Dudley, F.R.S., for permission to publish; the Medical Officer in Charge of this Hospital, Surg. Rear-Admiral H. R. B. Hull; the Senior Medical Officer (Surgical), Surg. Captain W. Kendall, V.D., R.N.V.R.; and finally the Senior Medical Officer of the patient's ship, Surg. Lt.-Cmdr. D. C. Lavender, R.N.V.R.

## REFERENCES

- COPE, V. ZACHARY (1915), *Brit. J. Surg.*, 3, 55.  
 — (1938), *Actinomycosis*, 161. Oxford University Press.  
 McWILLIAMS, CLARENCE A. (1917), *Ann. Surg.*, 66, 117.

## SUTURE OF LACERATION OF INFERIOR VENA CAVA DUE TO BOMB SPLINTER

By H. A. KIDD

MEDICAL SUPERINTENDENT, KINGSTON COUNTY HOSPITAL, KINGSTON-ON-TIAMES

INJURIES of the inferior vena cava may be due to : (1) Penetrating wounds; (2) External violence without penetration; (3) Injury during surgical operations.

A number of cases due to the last cause have been recorded, but recovery from hæmorrhage due to the first two is uncommon. This is no doubt due to the time factor and to the presence of other abdominal lesions which may of themselves prove fatal. Recovery after a penetrating wound from flying-bomb fragments is here recorded.

## CASE RECORD

H. N., aged 35, a soldier, was admitted to the Kingston County Hospital on June 30, 1944, after injury by a flying bomb. Shock was marked, the temperature being 100° F., pulse 97, respiration 20, and there was a penetrating wound in the back, over the right third lumbar transverse process. The abdomen was tender and an intra-abdominal lesion was thought to be present. Morphine gr. † and a blood transfusion were given for shock, together with A.T.S. 1000 units. Radiography revealed the presence of two foreign bodies, one in the posterior abdominal wall, the other about 2 in. in front of the bodies of the second and third lumbar vertebra. The abdominal tenderness increased, and operation was performed six hours after injury.

**FIRST OPERATION.**—Under pentothal, gas, oxygen, and trilene, the wound in the back was explored and admitted two fingers. There was a fracture of the transverse process of the third lumbar vertebra. The wound edges were excised, and a few sutures

inserted, together with a drainage tube and sulphamide powder. There was a continuous ooze of blood through the tube.

The abdomen was then opened through a right paramedian incision. No free blood or evidence of perforation of the alimentary tract was found. The mesocolon was distended with blood, but the intra-abdominal foreign body could not be palpated. The hæmorrhage was entirely retroperitoneal, so the caecum and ascending colon were mobilized. As the post-parietal peritoneum was stripped off there was a rush of dark blood, which welled up and filled the wound. Suction was used, and an assistant compressed the vena cava, which lessened the hæmorrhage. Further dissection, which included mobilization of the junction of the second and third parts of the duodenum, revealed a tear in the inferior vena cava, about 1½ in. long. A vein was seen entering the vena cava at the top of the tear, and it was not certain whether this was the renal vein or the spermatic; it was later found to be the latter, and was ligatured. Compression and strong suction improved the field of vision, but hæmorrhage from the upper end of the vena cava was troublesome, and was lessened by putting the patient in the Trendelenburg position. An attempt was made to suture the vena cava with fine silk, but it was found that as the rent became closed the connective tissue covering obscured the wound edges. The stitches were therefore removed, and the vein dissected free. The wound could then be sutured with continuous vaselined silk.

**PROGRESS.**—The patient's condition was very poor, the pulse being about 140, and almost imperceptible at the wrist. Five pints of blood were given during the operation, and over six removed by the sucker. The abdomen was closed without drainage, and no

further search was made for the foreign bodies. Heparin was not given, owing to the presence of the open wound in the back.

The patient's condition gradually improved, but he had severe hæmaturia and complained of abdominal pain. The hæmaturia cleared up in 48 hours, and

escape from the wound in the back, which was almost healed. The drainage was improved, and the temperature settled.

On Nov. 24 the wounds were soundly healed, with no discharge. His general condition was good, and he was recommended for discharge.

## DETAILS OF REPORTED CASES

AUTHOR	DATE	CAUSE	SEX	AGE	TIME BEFORE OPERATION	TREATMENT	SITUATION	CONCOMITANT INJURIES	RESULT
1. Taylor	1916	H.E.	M.	Young Soldier	12 hours	Not discovered at operation	Below rt. renal vein	Laceration of liver	Died
	1916	Bomb	M.	Young soldier	3½ hours	Forci-pressure hæmorrhagic Suture	3 in. below rt. renal vein	—	Recovery
2. Rosenstein	1922	Fall without penetrating wound	M.	6	Not stated	—	Left side	None	Recovery. Developed large hydro-nephrosis requiring further operation
3. Sheppe	1922	Bullet wound	M.	41	Not stated	Suture	Below renal vein	Perforation of intestine	Died from peritonitis. Bullet plugged wound in vena cava, and slipped on, passing into right ventricle
4. Sala	1924	Knife wound	F.	—	Not stated	Suture	—	Intestinal perforation	Recovery
5. Pfaff	1926	External violence	F.	41	10 days	Ligature of vena cava	Just above commencement of vena cava	Rupture occurred into ovarian cyst	Recovery
6. Wurzel	1931	G.S.W.	M.	30	Not stated	Suture	Right side vena cava	—	Recovery
7. Barnes	1938	Wound (?) stab	F.	10	Several hours	Ligature	Level of L.4	Perforation of intestine	Recovery
8. Stor	1939	Bullet wound	M.	17	Not stated	Suture	Right side level of L. 2-3	—	Recovery
9. Hartzell	1940	Knife stabs	Negro M.	41	Not stated	Suture	Below renal vein	—	Recovery
10. Kidd	1945	Flying-bomb fragment	M.	35	6 hours	Suture	Level rt. spermatic vein	Right kidney	Recovery

was probably due to damage to the kidney by one of the bomb fragments. In 24 hours the pulse-rate was down below 90, and the temperature ranged between 97.2° and 99° F. Abdominal distension was relieved by a Ryle's tube, and intravenous glucose saline was given for six days. There was a discharge of pus from both the wound in the back and the abdominal incision. His general condition improved, but culture of the wound yielded *Staph. aureus*. It was decided to remove the foreign body which was causing the persistent sinus in the back, and a pre-operative course of penicillin was given.

**SECOND OPERATION.**—On July 26, under pentothal, gas, oxygen, and novocain, an incision was made in the loin, and one of the foreign bodies extracted from the psoas muscle. The wound was sutured with a small drain for the injection of penicillin.

**PROGRESS.**—Recovery was uneventful, and the wound culture became sterile, penicillin being given parenterally and locally for ten days. The stitches were removed on the tenth day, and the patient was transferred to a convalescent hospital. Four days later the temperature rose, and there was intermittent pyrexia followed by a discharge of pus from both the lumbar and abdominal wounds.

He was re-admitted to hospital; thought to be due to a mild osteomyelitic condition at the site of the fractured transverse process. The pus from this area had tracked along the abdominal wall, being unable to

## COMMENT

The literature contains records from nine authors of 10 cases of injury, with 8 recoveries.

Pfaff (1926) gives a résumé of the results of different types of treatment of injury of the inferior vena cava during operation.

	Recovered	Died
1. Suture	5	2
2. Ligature of vena cava	13	6
3. Forci-pressure	6	0
4. Packing	0	1

Ligation is only practicable below the entrance of the renal veins, but in no case after ligation did œdema of the legs persist. It would, therefore, appear that where time is of importance the simpler procedure of ligation of the vena cava may be safely resorted to.

Interesting features of the cases due to external violence or penetrating wounds are the lapse of time between the injury and operation, and the operative findings, which reveal that in the large majority only a relatively small amount of hæmorrhage had occurred. It is not until the surgeon exposes the injured vena cava that there is profuse bleeding. Taylor (1916)

suggests that this is due to the wounds in the vena cava and the overlying peritoncum not being superimposed, but it would seem possible that the intra-abdominal pressure is also a factor, rigidity of the abdominal muscles being present and the shock causing a considerable fall in blood-pressure. When an abdomen has been opened, before a retroperitoneal hæmorrhage is explored, provision should be made for blood transfusion, adequate access to the site of injury, and good illumination, and the requisite suture materials (fine vaselined silk) prepared.

### SUMMARY

1. Nine cases of recovery following injury to the inferior vena cava have been recorded.
2. Intra-abdominal or retroperitoneal hæmorrhage is not usually large in amount.
3. Manipulations by the surgeon in verifying the site of the lesion cause profuse hæmorrhage.

4. Ligature of the inferior vena cava below the renal vein may be safely resorted to in a difficult case.

5. If a retroperitoneal hæmorrhage is discovered during the course of a laparotomy, it should not be explored until preparation has been made for control of profuse hæmorrhage from the injured vessel.

### REFERENCES

- BARNES, W. A. (1938), *Virginia med. Mon.*, **65**, 285.  
 HARTZELL, J. B. (1940), *Ann. Surg.*, **111**, 659.  
 PRAFF, O. G. (1926), *Amer. J. Obstet. Gynec.*, **11**, 660.  
 ROSENSTEIN, P. (1922), *Z. urol. Chir.*, **9**, Orig. 102.  
 SALA, A. (1924), *Riv. osped.*, **14**, 85.  
 SHEPPE, W. M. (1922), *J. Amer. med. Ass.*, **78**, 1890.  
 STOR, O. (1939), *Chirurg*, **11**, 725.  
 TAYLOR, D. C. (1916), *Lancet*, **2**, 60.  
 — (1917), *J. R. Army med. Cps.*, **28**, 274.  
 WURZEL, P. (1931), *Cas. Lék. íes.*, **70**, 919.

## VOLVULUS OF THE SMALL INTESTINE DUE TO A MECKEL'S DIVERTICULUM

By RODNEY SMITH, MAJOR, R.A.M.C.

AN acute abdominal catastrophe as a result of the presence of a Meckel's diverticulum, though uncommon, is not of very great rarity. Volvulus of the diverticulum, with or without involvement of the coil of ileum bearing it, is well recognized as a possible accident, and is one of the ways in which the diverticulum may precipitate acute obstruction of the small gut. There are several unusual features about the following case, which is of sufficient interest to be worth recording.

### CASE REPORT

**HISTORY.**—W. B., a gunner of 36, had never before had symptoms referable to the intestinal tract. Four months ago he had been admitted to hospital with malaria, blood slides being positive, and after routine treatment had been discharged cured. Eight days ago he had been readmitted with a relapse of the malaria, with a temperature of 104.4° and blood slides again positive for malarial parasites. Since then he had remained in a Field Ambulance under treatment with quinine and pamaquin. Temperature had settled after 36 hours and remained normal.

Eleven hours before admission, at 5 a.m., he was seized with a sudden very violent abdominal pain which was generalized, intermittent, and gave place to a persistent ache of no great severity between the bouts of very acute pain. He had vomited at once and at frequent intervals since, the later vomits containing much bile. There had been one loose motion soon after the onset of the pain. He was sent, as an acute abdomen, to a Field Surgical Unit.

**ON EXAMINATION.**—The patient appeared very ill, with a grey, sunken facies, anxious expression, and stains of bile around the nares and on the chin. The tongue was dry and furred and the breath offensive. Temperature was 99.6° and the pulse

92, of good volume but irregular on account of extra-systoles. During examination there was a sudden spasm of very acute pain lasting 30 seconds. Examination of the abdomen revealed considerable distension, generalized tenderness, and guarding, but no true rigidity; no spleen or other abnormal mass palpable. There was very marked 'rebound tenderness'. No intestinal sounds whatever were heard, even during the attacks of colic. Nothing abnormal was found per rectum or at the hernial orifices.

Without the history of malaria the only difficulty in diagnosis would have been in deciding the precise nature of the abdominal catastrophe that had occurred. In the presence of this history there was some hesitation in making a double diagnosis, and it was seriously considered whether or not this was a case of an acute abdomen simulated by intestinal capillary thrombosis, such as may occur in malaria and of which the manifestations are notoriously misleading. The possibility was also considered of the colic being a toxic phenomenon due to the administration of pamaquin. However, examination of blood slides showed that there were now no longer malarial parasites to be seen, and a white-cell count showed 19,000 leucocytes, 89 per cent polymorphs. Immediate laparotomy was decided upon with a diagnosis of acute obstruction of the small gut. The precise type of obstruction was more difficult to determine, the leucocytosis and absence of intestinal sounds suggesting the presence of peritonitis and the lack of abdominal rigidity being against this. The general condition of the patient, too, appeared very much worse than that usually seen in a case of strangulation in a hernia or by a band. A tentative diagnosis was made of mesenteric thrombosis of a medium-sized loop of small gut with gangrene.

**OPERATION.**—An intravenous saline drip was started in the theatre and the patient anesthetized

with chloroform and ether, followed by ether in a vaporizer. The abdomen was opened by a long right paramedian incision. The stomach, small gut, and large gut as far as the splenic flexure were greatly dilated and the transparent coils of small gut were seen to be distended with gas and liquid. There was no sign of organic obstruction at the splenic flexure, but the large gut distal to it was empty and contracted. There was a thin serous peritoneal exudate. The cause of the obstruction was found to be a volvulus of a 5-in. long Meckel's diverticulum. From the apex of the diverticulum a slender band some 1 in. long ran to the posterior abdominal wall in the right iliac fossa. This appeared to be inflammatory in origin, and there were in addition numerous calcareous glands in the mesentery. Anchored at its apex by this band, the diverticulum had rotated about its long axis and taken up in the volvulus the knuckle of ileum from which it arose. After cutting the detaining band the diverticulum and the loop bearing it were easily drawn into the wound and untwisted, when it was found that there were gangrenous patches on the diverticulum and on the anti-mesenteric border of the gut at its base, a doubtful area on the mesenteric border of the ileum 4 in. proximally, and thrombosis of the mesenteric vessels of the loop. Resection of the whole of the loop bearing the diverticulum was carried out, followed by end-to-end anastomosis; 10 g. of sulphadiazine suspended in saline was placed around the anastomosis and in the peritoneal cavity, and the abdomen was closed without drainage. A Ryle's tube was passed into the stomach.

After operation the Ryle's tube was connected to an apparatus for continuous suction drainage and the intravenous drip was continued with alternate pints of saline and 5 per cent glucose-saline. As soon as the patient was conscious he was propped up in bed and given morphine (gr.  $\frac{1}{2}$ ) and thereafter morphine (gr.  $\frac{1}{2}$ ) 6-hourly. After allowing 36 hours for the absorption of sulphadiazine from the peritoneal cavity to pass its peak, 3 g. of sulphadiazine was given intravenously 6-hourly for 72 hours. The post-operative course was uncomplicated. Temperature and pulse were normal after 48 hours, by which time the patient had quite lost his previous toxic and dehydrated appearance. The tongue was clean and moist and the urinary output satisfactory. On the third day the morphine was reduced to gr.  $\frac{1}{8}$  8-hourly, and on the fourth day to gr.  $\frac{1}{8}$  12-hourly. On the fifth day some discomfort was caused by abdominal distension, but this was speedily relieved by a small turpentine enema, with the passage of much flatus. No further injections of morphine were given. On the seventh day renewed distension caused some anxiety for 24 hours, but was confined to the large gut and subsided with a natural bowel action. On the eighth day gastric suction and intravenous drip were discontinued. Sutures were removed on the twelfth day and the wound was soundly healed. The patient was evacuated to a general hospital fifteen days after operation, where further convalescence was uneventful.

### COMMENTS

There are several points of interest in this case.

**1. Diagnosis.**—This was not made any easier by the fact that the patient had had a symptomless diverticulum for 36 years and that the onset of trouble should coincide with a proved attack of malaria, which is known to

produce on occasions obscure abdominal signs and symptoms simulating an acute abdomen. In such cases a white-cell count may be of great value. In this particular case negative blood-slides for malarial parasites and a leucocytosis of 19,000 made laparotomy inevitable.

**2. Pathology.**—The diagnosis of small-gut obstruction was confirmed at laparotomy. The precise type of obstruction was, however, not diagnosed. Yet this could have been diagnosed. Although at operation the condition was found to be one of strangulation and gangrene, it had started as an obstruction at the base of a Meckel's diverticulum—in other words, a 'closed-loop' obstruction. As in experimental animals, the immediate result was violent peristaltic spasms of the obstructed loop combined with a widespread ileus of the rest of the gut. Before operation the combination of violent intestinal colic and absence of peristaltic sounds had been noticed and commented upon. A diagnosis of 'closed-loop' obstruction could have been made. The appearance of the gut on opening the abdomen agreed with the physical signs and the known pathology of this type of obstruction. There was complete absence of peristalsis over the whole of the small and large gut, which was greatly dilated except for the colon distal to the splenic flexure, which had emptied once and remained in spasm.

**3. Treatment.**—The necessity for resection in the presence of gangrene of the gut needs no discussion. Apart from the use of intraperitoneal chemotherapy, the survival of this patient is due not to any detail of surgical technique, but to the very great improvement in the last few years in the post-operative care of such cases, the details of which are rapidly becoming standardized. Suction drainage, continued at least until the patient has been tided over the critical period of the 4th and 5th day after operation, is absolutely essential, and as long as suction drainage is employed the fluid intake by mouth must be supplemented by an intravenous drip. Evidence is not lacking (Hudson et al., 1941, 1942) to show that the likelihood of post-operative peritonitis is considerably reduced by the routine use of intraperitoneal chemotherapy, and reinforcement by the intravenous route is of probable, though less certain, value. Regular small doses of morphine for the first four or five days help to provide a smooth convalescence, adding to the comfort of the patient and the ease of tolerating an indwelling gastric tube, and, in the small doses used, promoting the resumption of peristalsis by mildly stimulating the gut, where larger doses may have the reverse effect by causing spasm of the circular muscle.

### REFERENCES

- HUDSON, R. V., and SMITH, RODNEY (1942), *Lancet*, I, 437.  
— — — and SELBIE, F. R. (1941), *Ibid.*, I, 438.

# THE BRITISH JOURNAL OF SURGERY

## A CASE OF REGIONAL ENTERITIS IN CHILDHOOD

BY DENIS EBRILL

RESIDENT ASSISTANT SURGEON, ST. GEORGE'S HOSPITAL, LONDON, S.W.

NON-SPECIFIC regional enteritis is not a remarkably uncommon condition. A review of the available literature indicates that the disease is very rare in childhood. The following case, which occurred in a child aged 9 years, presented a number of unusual features prior to operation, and gave rise to some doubt as to the correct line of management. For these reasons it is thought to be worth recording.

### CASE REPORT

**HISTORY.**—E. G., a girl aged 9 years, attended the Out-patient Department on Dec. 17, 1942. She had complained of abdominal pains three days previously and had been off her food since then. The pain was comparatively slight, but was associated with vomiting. These symptoms recurred every day, but the child was well enough to attend school. Her bowels had been confined since the onset of symptoms. There was no history of any previous abdominal trouble. The past medical history and family history showed no relevant features. Examination showed normal temperature and pulse. The only positive findings were a slight tenderness in the right iliac fossa on deep pressure and some tenderness in the region of the descending colon.

The following day, as abdominal pain and vomiting continued, she was admitted for observation. Her general condition was unchanged, but tenderness appeared to be greatest in the neighbourhood of the umbilicus.

During the next few days she had frequent attacks of colicky abdominal pain lasting about three-quarters of an hour. She vomited during the attacks, but in the intervals appeared quite well. The leucocyte count was 9700 and routine examination of urine revealed no abnormality.

Ten days after admission, Jan. 28, 1943, her condition was again reviewed. There were no fresh physical signs, but she was obviously losing ground through continued vomiting. She was afebrile and her pulse-rate was unchanged, but a leucocyte count now showed 19,300 cells with 84 per cent polymorphs. A laparotomy was considered advisable, a tentative pre-operative diagnosis of either atypical appendicitis or tuberculous abdominal glands being made.

**FIRST OPERATION (D. E.).**—Under general anaesthesia, a right paramedian incision revealed some free fluid in the peritoneal cavity. The appendix and adjacent bowel were congested, but it was felt that this was not enough to account for the child's symptoms. Appendicectomy was performed. The small intestine was then examined: 3 ft. from the caecum an abscess cavity was discovered among the coils of small gut. About 2 oz. of white creamy pus were mopped up.

The origin of the trouble proved to be a small perforation leading from the region of the mesenteric attachment into an indurated mass about the size of a broad bean. This mass could be felt projecting into the lumen of the gut, but did not appear to be causing obstruction. The gut above was not hypertrophied, but for about 6 in. the bowel above and below the lesion was thick and oedematous and

showed evidence of acute inflammation (Fig. 455), with petechial haemorrhages under its serous coat. A probe was passed into the track for about one-third of an inch, but its point could not be felt in the lumen.

Oedematous small gut with petechial haemorrhages under serous coat

Indurated mass palpable through bowel wall

Opening of sinus with track. Origin of intra-peritoneal abscess

Palpable lymphatic glands

FIG. 455.—Sketch of condition present on laparotomy.

The pathology of the condition was by no means clear. The possibilities of perforation by a foreign body, growth, tuberculous process, and Crohn's disease were considered. On account of the sepsis present it was evident that resection would be unduly hazardous: the perforation was therefore closed by a stitch and oversewn with a piece of omentum. The abdomen was closed with drainage and an intravenous glucose-saline drip set up.

**PROGRESS.**—The early post-operative period was uneventful, nor was there any fresh clue as to the diagnosis: the Mantoux reaction and the Widal reaction were both negative. A swab taken of the pus at operation proved sterile on culture.

On Feb. 17, 1943 (20 days after operation), the child started to have attacks of abdominal pain and vomited twice. Her leucocyte count was 12,000.

**SECOND OPERATION.**—The following day, as her condition was no better and the clinical features suggested obstruction, the abdomen was reopened. The peritonitis had resolved without much adhesion formation. The diagnosis of obstruction was confirmed. On tracing up the lower collapsed bowel the area of gut involved was again examined. The appearance was changed only in so far as there was now no evidence of inflammation apart from some enlarged glands in the mesentery. The gut above the lesion was dilated.

Resection of 6 in. of small bowel with an end-to-end anastomosis was carried out. Following operation she had blood and glucose-saline by slow drip. Her post-operative condition was entirely satisfactory and gave rise to no further worry. She was discharged on March 25.

The child was seen recently and is completely symptom free.

**PATHOLOGY.**—Examination of the resected gut was carried out. The indurated mass appeared to involve all the tissue between the mucosa and the serous coat. There was one area where the mucosa was ulcerated. A probe passed into this could be felt beneath the serous coat at the spot where the original perforation had been closed.

## REGIONAL ENTERITIS IN CHILDHOOD

513

The histological features were reported on as follows: "The mucosa shows marked degeneration, many cells containing large mucous vacuoles. In the deeper layers there are small areas of intense congestion showing polynuclear and round-celled infiltration. The muscular wall shows small hæmorrhages as well as areas of necrosis and small abscesses containing a mixture of large mononuclear and polynuclear cells. Beyond this is fatty tissue; some

However, comparatively few have been written up and hospital records are not readily available, partly owing to the present lack of clerical staffs and partly owing to the evacuation of many hospitals to safer areas.

From the clinical point of view the onset is of interest. It is rare for this condition to start with acute symptoms. The majority of cases present a history of chronic vague abdominal trouble which antedates by a long period the development of physical signs. This statement is true at least for adults, although there is some evidence that an acute onset, resembling appendicitis, is more usual in childhood. Perforation in itself is quite a common complication of regional enteritis, but it usually occurs during the more chronic stages of the disease. Discovery and closure of the perforation at the first operation greatly simplified the subsequent management, as drainage alone would probably have resulted in an abdominal sinus with increased danger.

From an aetiological point of view the results of our investigations have a certain interest. The occurrence of this lesion in association with a negative Mantoux reaction, though not in any way conclusive, is further evidence against the view, once widespread, that these lesions were atypical tuberculous reactions.

Reviewing the pathological features noted, both at the time of the first operation, and in the specimens obtained, it appears likely that the initial lesion was an abscess, which developed in the submucous layer of the terminal ileum in the neighbourhood of its mesenteric attachment. Extension of infection, along the lymphatics or blood-vessels, would allow this to discharge through the serous coat in the region of the mesentery, with the production of the localized intraperitoneal abscess. Having closed off this sinus by suture and omental patch, subsequent extension of the abscess was presumably in the direction of the lumen of the gut, eventually producing the small ulcerated area found in the specimen. (This, of course, might have occurred in time even without interference, with the drainage of the abscess, and would explain perforations sometimes seen in this condition.) All the other changes in the bowel could be secondary to chronic inflammatory reactions in the lymph-glands draining the segment. (The latter would also explain extension of these secondary pathological processes to neighbouring bowel primarily unaffected.) The cause of such an abscess is impossible to determine. Blood-borne infection may be the solution. The negative result on routine culturing of the pus from the abscess would fit in with C. G. Mixer's suggestion (1935) that this condition is due to infection by an anaerobic streptococcus.

It is difficult to see how the pathological features presented by this case could be explained if the initial change was a lymphoreticular hyperplasia affecting the lymphoid follicles of the intestine and the glands of the mesentery.



FIG. 456.—Section showing diffuse inflammatory reaction. A well-marked giant cell is present.

of it seems the result of organizing hæmorrhage. In this outer zone is an area showing many giant cells. "I see no evidence of tuberculosis. I am of the opinion that this is an example of early Crohn's disease with some of the changes attributable to operative treatment." (Fig. 456.)

### DISCUSSION

Crohn's disease in a child of this age seems to be distinctly rare. In a series of 178 cases studied in the Mayo Clinic (1941) only 3 were under 10 years of age; while the records of the Boston Children's Hospital include but 1 case of Crohn's disease (Ladd and Gross, 1941).

In a series of 48 cases reported from the Lahey Clinic (1942), the youngest patient was aged 16. The occurrence of this condition in an infant of 18 months is reported in Holt's *Diseases of Children* (1940).

In this country figures for any large series are not available. Those which have been studied indicate that at this age the condition is uncommon. There has not been a case at the Victoria Hospital, Tite Street, during the last ten years. F. W. M. Pratt and S. L. Simson (1942) quote a case in a child aged 7 years, and one of their cases, though 18 at the time of operation, had a very similar sort of attack at the age of 11. Probably these few examples give a false impression of the rarity of the condition, as many more cases have certainly occurred.



An infective basis for this condition would appear to accord more with the reports that cases presenting the typical naked-eye appearances of Crohn's disease have undergone spontaneous resolution. If the initial lesion in Crohn's disease is infective in nature and localized in the bowel, then a case such as this in which early resection is performed should carry an excellent prognosis, as far as freedom from recurrence is concerned.

### SUMMARY

A case of Crohn's disease in a child aged 9 years is described.

A full account is given of the operative findings and subsequent course of the case.

Some interesting features are discussed.

My thanks are due to Dr. Pinckney for his help and encouragement and to Dr. John Taylor for the pathological examination.

### REFERENCES

- Collected Papers of the Mayo Clinic* (1941).  
 HADFIELD, G., and GARROD, L. P. (1942), *Recent Advances in Pathology*.  
 HOLT (1940), *Diseases of Infancy and Childhood*, 4th ed.  
 LADD and GROSS (1941), *Abdominal Surgery of Infancy and Childhood*.  
 MIXTER, C. G. (1935), *Surgery*, 102, 674.  
 PRATT, F. W. M., and SIMPSON, S. L. (1942), *Brit. med. J.*, 1, 634.  
*Surgical Practice of the Lahey Clinic*, 1942.

## DELAYED PARAPLEGIA FOLLOWING FRACTURES OF THE VERTEBRÆ

BY LAMBERT ROGERS, SURGEON CAPTAIN, R.N.V.R.

PROFESSOR OF SURGERY, UNIVERSITY OF WALES

WHEN paraplegia complicates a vertebral fracture it is usually a concomitant condition produced at once by the cord being nipped by a to and fro movement of one vertebral body on its neighbour. Rarely the onset of paraplegia is delayed so that there is an interval between the time of injury and that of the appearance of the symptoms of a spinal cord lesion. During this interval conduction in the cord is unimpaired, its functions are normally discharged, and it would appear to have escaped damage. Numbness and paralysis then supervene, however, and may be either transient or lasting.

The following are illustrative cases. They have been characterized by an interval between the injury to the back and the onset of the paraplegia. The delay in the appearance of symptoms is sufficiently unusual to excite comment and arouse speculation as to the nature of the pathological processes involved.

Three instances occurred in Naval personnel, the fourth in a young woman. Two were due to cycling accidents, one to a crash in a fighter aircraft, and the other occurred as the result of a ship being torpedoed. Two patients have recovered completely, two only partially.

### CASE REPORTS

**Case 1.**—Blown up by torpedo explosion, walked to ship's side, clambered overboard and swam away from ship; then became paraplegic.

On Dec. 12, 1943, a seaman, aged 22, was standing on the quarter-deck of his ship when a torpedo struck the side just below him. He next remembers sitting on the deck in a natural position, but does not know whether or not he was thrown into the air. His first impression was that he had not been injured at all. As the ship was sinking he got up, walked to the side,

and climbed over, letting himself down into the water. After swimming about five strokes his legs suddenly became paralysed, so that he could neither feel nor move them. He felt no pain in his back. He succeeded in reaching the ship again and pulled



FIG. 457.—Case 1. Crush fracture, L.1.

himself on board. He could feel nothing from the waist down. He was later transferred from the sinking ship to a raft, thence to a dinghy and a corvette, and later that evening admitted to a hospital on shore. It was then noted that he had a tender swelling over the first lumbar vertebra, and X rays showed that the body was wedged. He now had retention of urine. Eight days later the deformity was reduced by the two-table method and a plaster jacket applied. Suprapubic cystostomy was performed. Four months after the injury there had been little if any change in

# DELAYED PARAPLEGIA IN SPINAL FRACTURES

515

the paraplegia. He was incontinent of urine and faeces, with sensory loss in the distribution of L.5 and the sacral segments. He was unable to move either foot or toes. The body of L.1 was somewhat wedged (Fig. 457). He could flex and extend the knees and flex and adduct the hips, but extension and abduction movements of the hips were weak. Lumbar puncture showed a sluggish response to jugular compression and the protein content of the fluid was 55 mg. per cent.

*Laminectomy* (D.12, L.1, and L.2) on May 29, 1944, revealed compression of the spinal cord within these limits and that it was pushed backwards at L.1. On opening the dura mater an old contusion of the cord and cauda equina was found, the conus being adherent to the dura and the nerve-roots matted together. Adhesions were separated as far as possible and the wound closed.

*Progress.*—There was little improvement, the only motor change noted was ability to contract the extensors of the toes—some sensation to light touch was now present in the area of the buttocks previously anaesthetic. He was invalided out of the Service.

**Case 2.—Crash in Spitfire, pain between shoulders, no other sign or symptoms; paraplegia in 48 hours.**

A Sub-Lieutenant in the Fleet Air Arm, aged 22, made a crash landing in a Spitfire. He was not concussed and is clear about the incident. He discarded his harness, climbed out of the aircraft, and felt no ill effects except pain between the shoulders. He was admitted to a hospital in the vicinity of the crash. There were no abnormal neurological features. Forty-eight hours later both legs began to feel weak and numb. The numbness and weakness increased



FIG. 458.—Case 2. Crush fracture, D.3, D.4.

gradually. There was no sphincter disturbance. There was a partial flaccid paralysis of both lower limbs, the upper recti abdominis and the lower intercostals were partially paralysed. Abdominal reflexes were absent except for a slight flicker of the upper left. The left cremasteric reflex was absent, the right just present. Both plantar reflexes were of the right just present. There was a sensory level at D.10, pin-prick being blunted but not abolished below that level. Anaesthesia to cotton wool was apparent on the soles and toes of both feet.

Twenty-four hours later the weakness and numbness began to diminish. The right plantar reflex now become flexor, the left remaining extensor. From this time the paraplegia gradually subsided. He was placed on a plaster turning shell. Radiographs revealed a crush fracture of D.3 and D.4 (Fig. 458). Ten days later the cerebrospinal fluid obtained by lumbar puncture was normal (protein content 45 mg. per cent) and the Queckenstedt phenomenon was present and normal. He has made a complete recovery and returned to duty.

**Case 3.—Cycling accident, walked a mile, then sat because of pain in back; unable to rise because of paraplegia.**

An engine-room mechanic, aged 19, was cycling down a steep hill when he was thrown by his machine striking a loose stone. He cannot recall how he felt, but he says he was "winded" for about a minute. He



FIG. 459.—Case 3. Crush fracture, D.3, 4.

then picked himself up, but as his back felt sore he walked, wheeling his cycle, for about a mile. He then sat down because his back was more painful, and after sitting for about five minutes lay down on the grass. "As soon as I lay down I couldn't move." A passer-by sent for an ambulance and he was taken to hospital, where he was found to have a crush fracture of D.3 and D.4 (Fig. 459), hypaesthesia up to the ensiform cartilage, inability to move the lower limbs, and retention of urine, for which suprapubic cystostomy was performed. He was immobilized in a plaster turning case. On lumbar puncture Queckenstedt's phenomenon was present (i.e. no protein increase (60 mg.). Gradual recovery took place and the paraplegia completely passed off during the next few weeks. He has made a complete recovery.

**Case 4.—Bicycle in collision with car, picked herself up, taken by car to doctor's house, walked inside; numbness and paralysis.**

On March 17, 1944, a girl of 17 was knocked off her bicycle by a car. She picked herself up and was taken by car to her doctor's house. She walked inside, but soon afterwards began to feel numb and her legs became weak and useless. She was taken to

hospital and found to have complete paraplegia below the costal margin. X rays showed a crushed vertebral body, D.8 (Fig. 460). She was placed in a plaster turning cast, and on June 20 suprapubic cystostomy was performed. For a time she appeared to be progressing, some limb movements were apparent, and with these



FIG. 460.—Case 4. Crush fracture, D.8.

there was some sensory recovery, but as the condition then appeared to become stationary, and as there was no sign of recovery of the sphincters, operation was decided upon.

**Operation.**—On Oct. 6 laminectomy of D.7, D.8, D.9 was performed. Sclerosed bone was found constricting the spinal canal at the level of D.8, and when the dura was opened here it was seen that the cord was pushed backwards. It was noticed also that the posterior spinal veins were distended below the level and collapsed above it. As the current in these veins is upwards, this was an indication of obstruction at this site. Further examination by detaching a slip of dentate ligament and rotating and retracting the cord, revealed a conical hump of bone in front of it projecting backwards and displacing it towards the line of the neural arches. The dura was opened over this bony hump, and with rongeurs and chisel this was removed. The dura was left open, the muscles approximated with catgut, the aponeurosis with fine silk, and the skin likewise. The operation was conducted under intratracheal nitrous oxide and oxygen anaesthesia (Dr. F. Taylor) with the patient lying prone on the anterior half of a plaster shell.

### COMMENTS

We may summarize our knowledge of vertebral injuries and associated spinal cord lesions as follows:—

1. Vertebral fractures may at once produce cord injuries varying from mild contusion to complete severance.

2. On the other hand, vertebral fractures may be symptomless and only discovered when a patient who is quite unaware that he has fractured his spine is being X-rayed for some other condition. This has been well recognized in certain occupations, e.g., miners (Owen Rhys, 1934).

3. Gross injury of the spinal cord, even to the extent of a complete transverse lesion leading to the death of the patient, may be produced by a blow on the spine which has not produced a fracture of the vertebræ. This is exemplified by the following case:—

**Case.**—Blow on back of neck, vertebræ not fractured, paraplegia. Hæmatomyelia—complete transverse lesion.

A miner, aged 61, was struck on the back of the root of the neck by a falling pit prop at 10 a.m. on Feb. 24, 1944. He remembered the blow and was conscious of numbness and tingling in his arms and legs, but was unable to move them. He was carried out of the pit and taken to hospital, where it was found he had complete paraplegia and only slight movement in the arms. There was sensory loss below D.1. Radiographs of the cervico-thoracic region of the spinal column were negative. There was a gradual return of some sensation, but no motor recovery. Flexor spasms and pressure sores developed, and he died in May. An autopsy showed no fracture or dislocation, but there was a cystic area in the cord corresponding with the clinical level, filled with yellowish fluid regarded as old hæmorrhage.

4. The spine may be fractured without evidence of cord injury, but at a varying interval of minutes, hours, or even a day or two, paraplegia becomes apparent. This paraplegia may be either transient or lasting.

These cases of delayed paraplegia, such as the four here recorded, are apparently rare. Inquiry among surgical friends and colleagues has not been productive of further examples, but in studying the case histories of Sir William Thorburn's masterly clinical dissertation (1889), in which details of 45 cases of gross spinal injury are given, a case (No. 35) occurring in his practice is recorded:—

A man, aged 30, fell out of a cart on to his back in the road, striking the lumbar region against the curbstone. He got up, walked up stairs to the top of a warehouse, later drove home, and went to bed. During the day the limbs became partially paralysed and he lost control of the sphincters. The paresis passed off, but the sphincter disturbance remained.

Thorburn also quotes a case of Péan's recorded by E. Hart (1889):—

A man received a bite from a horse in the mid-dorsal region. At first this was supposed to be only a "pinch of the skin". After some days, however, nervous symptoms began to come on gradually, and these culminated in complete paraplegia with urinary retention and severe local pains. Péan operated and removed some fragmental neural arches and the patient was restored to almost his normal condition. Commenting on this case, Thorburn suggests that probably the broken arches were secondarily depressed by movement or pressure.

### DISCUSSION

What is the cause of the delayed paraplegia in these cases? In the transient cases it is probably due either to subpial hæmorrhage or to oedema, which, when fully established at a varying

interval after the injury, is sufficient to impair conduction in the cord. With absorption of the effusion in some 24 to 48 hours or even longer, according to the extent and severity of the lesion, conduction is once more restored. Such an explanation would appear to fit the facts in Cases 2 and 3. As they were not operated upon, however, it must remain speculative. Elsberg (1943) writes that hæmatomyelia may occasionally be delayed for some hours or even several days, and apparently even one or several months may elapse between the injury and the intramedullary hæmorrhage (Benda, 1929; Else Cohn, 1931; Foerster, 1936).

With Cases 1 and 4, however, paraplegia was delayed and persistent, and some light on the factors responsible was obtained from the findings at operation. In both of these cases bony compression was responsible for the persistent paraplegia, and in view of the case histories it would appear that this was the result of movement of the fragments subsequent to the initial fracture. Further movement of the displaced fragments had probably taken place as it might be expected to do in walking, say, with a fractured femur. Any deformity present would then naturally be expected to become worse and the displacement might bring about cord symptoms. That this does not often occur, however, is shown by the fact that old and symptomless fractures of vertebræ are frequently discovered. Owen Rhys, of Cardiff (1934), has reported a series of 270 cases of fracture in the dorsal and lumbar regions of patients who during a period of five years walked into his consulting room. None of these had sustained serious cord injury, most were unaware that they had had vertebral fractures.

It has already been remarked that these cases of delayed paraplegia are rare, but their mere occurrence suggests that the complication is one to which any patient with a fractured spine may be liable, and the question arises, therefore, can this delayed paraplegia be prevented? There can be little doubt that in its more serious forms, i.e. where bony deformity and later displacement has produced a delayed contusion of the cord, early recognition of the fracture and appropriate reduction and fixation would have prevented the further displacement and obviated the cord lesion. As the patients themselves were unaware of the fracture and brought about the displacement by in the one case swimming, in the other walking some distance, it is unlikely that this paraplegia can be avoided unless every patient who sustains a probable spinal fracture is kept lying in the position in which he was knocked over until radiology has shown an absence of fracture—a manifestly impossible condition. In the transient cases, moreover, if the suggested explanation is correct, no amount of immediate fixation is likely to abolish the oedema and effusion, which in any case appears to be absorbed rapidly. A more important problem is how to

handle one of these patients who has developed a late lesion. This question arose particularly in Case 3 of this series. When seen in hospital, paraplegia had developed after the patient had walked a mile following his accident, and there was good reason, therefore, to believe that late displacement had taken place in the spinal column, and any movement might increase this and perhaps render a mild, or at least incomplete, lesion more extensive or even complete. The patient was therefore kept lying flat on his back just as he had been brought to hospital, while an anterior plaster shell was made. He was then turned on this so that no movement of the spine took place, and the shell was completed posteriorly. It was then possible to handle him with impunity for X-raying, lumbar puncture to ascertain whether spinal block was present or not, and other investigations.

### SUMMARY

1. Four cases of vertebral fracture are reported in which paraplegia occurred after an interval in which there were no cord symptoms.
2. Such cases are rare.
3. In 2 cases the paraplegia was transient, resolving completely in a few days' time. In the other 2 cases it was persistent, and exploration was carried out with improvement in both following the removal of bony encroachment on the spinal canal.
4. An explanation is advanced for the occurrence of this delayed paraplegia.
5. Persistent delayed paraplegia is an indication for operation and removal of the bone block produced by displacement of the vertebral fragments.

I am indebted to the Medical Director-General of the Navy, and the Surgeon Rear-Admiral at a Naval Hospital for facilities for dealing with three of the patients, and Mr. H. Chitty for referring the fourth. For their assistance with details of the cases I am indebted to Surgeon Commander F. E. Stabler, V.D., R.N.V.R., Surgeon Lieutenant-Commander C. Langmaid, R.N.V.R., and Surgeon Lieutenant-Commander C. G. Scorer, R.N.V.R., and also to Mr. Arnold Aldis and Miss E. M. Wagstaff.

### REFERENCES

- BENDA, E. (1929), *Nervenarzt*, 2, 28.  
 BROCK, S. (1943), *Injuries of the Skull, Brain and Spinal Cord*. 2nd ed. Baillière, Tindall & Cox.  
 COHN, E. (1931), *Arch. ges. Psychol.*, 95, 439.  
 ELSBERG, C. A. (1940), *Injuries of the Skull, Brain and Spinal Cord* (ed. Brock), 19, 463.  
 FOERSTER, O. (1936), *Handbuch der Neurologie*, 5, 1. Berlin: J. Springer.  
 HART, E. (1889), *Brit. med. J.*, 1, 672.  
 RHYS, OWEN L. (1934), *Ibid.*, 1, 655.  
 THORBURN, SIR W. (1889), *A Contribution to the Surgery of the Spinal Cord*. London: C. Griffin.

## FURTHER OBSERVATIONS OF THE CLINICAL VALUE OF A GROWTH-PROMOTING SUBSTANCE IN WOUND TREATMENT

BY CAPT. H. WERNER, R.A.M.C.

SINCE the report by Lieut.-Col. A. B. Kerr and the author on the clinical value of a growth-promoting substance in the October, 1944, number of the JOURNAL (p. 281), a further 44 cases have been treated with Heart Extract Powder (H.E.P.). All the cases have shown indolence and intractability towards orthodox treatment. The use of tissue extract was again, as previously described, confined to wounds which had been treated for a period of at least six weeks unsuccessfully. The majority of the lesions responded favourably to the treatment. Four cases can be classified as failures—three ulcers and one chronic wound. The same three groups as previously described were treated: (1) Ulcers, (2) Wounds by projectiles, (3) Burns.

In the last report it was mentioned that there was no opportunity to treat a control series of wounds subjected to previous treatment with penicillin. In the present series, 6 cases, which had been subjected to prolonged treatment with crude penicillin, responded successfully to H.E.P.

### CASE REPORTS

#### CASES PREVIOUSLY TREATED WITH CRUDE PENICILLIN

*Case 1.*—Pte. K. R. Shell wound of leg, January, 1941. The wound over anterior surface of the tibia had healed very slowly, and after discharge from hospital broke down again in August, 1941. In spite of intensive hospital treatment since then (a year) no healing of the wound had been achieved. Last admission to this hospital, Dec. 28, 1943. Treated with Thiersch graft (failed), sulphanilamide, 3 weeks crude penicillin. No progress was achieved. On Feb. 10, H.E.P. was applied on a raw area of 3 sq. cm. Healing resulted in 5 days. The patient was discharged to his unit.

*Case 2.*—L/Cpl. G. F. Admitted this hospital, Nov. 24, 1943. In September, 1942, knocked his right elbow. An ulcer formed over the olecranon bursa which resisted all treatment with sulphanilamide, sodium sulphate, 4 pinch-grafts, secondary suture; treatment in another hospital for 3 weeks with crude penicillin. The area of 2 sq. cm. healed in 7 days after the application of H.E.P.

*Case 3.*—Gnr. F. R. Admitted this hospital Nov. 11, 1943. On Nov. 2, 1942, admitted to a British C.C.S. with desert sores of right popliteal fossa. Treated unsuccessfully in various hospitals with sulphanilamide, sulphathiazole, and sulphapyridine per os and locally. Complete immobilization in P.O.P. and several grafts were equally unsuccessful. Crude penicillin was applied for a period of 3 weeks without apparent success. H.E.P. led to the closure of the ulcer from 300 sq. cm. to 10 sq. cm. The ulcer, which is not yet healed, shows daily satisfactory progress.

*Case 4.*—L 'Cpl. H. Admitted this hospital, Dec. 8, 1943. Mine wound, Oct. 18. Wound on inner aspect of left leg below the knee. Treatment with sulphanilamide, flavine, eusol, and for 3 weeks with crude penicillin led to slight improvement only. The wound of 4 sq. cm. healed in 6 days under H.E.P.

*Case 5.*—Sgt. G. L. Admitted this hospital March 21, 1944. Knocked the shin in October, 1943. An ulcer formed on this place and was treated unsuccessfully from October, 1943, to March 21, 1944, in another hospital, with sulphanilamide, acriflavine, vaseline gauze, ultra-violet irradiation, 3 weeks' crude penicillin. H.E.P. was applied on March 25. On April 4 the three ulcers which were present on the anterior surface of the tibia had diminished in size from 6 sq. cm. to 1.5 sq. cm.

*Case 6.*—Pte. F. L. Admitted this hospital, Dec. 8, 1943. Shell wound buttock, Sept. 27. Treatment with sodium sulphate, vaseline gauze, acriflavine, sulphanilamide, and 4 weeks' crude penicillin, left a non-healing wound 1 cm. deep and 2 sq. cm. in surface. This wound healed in 12 days after application of H.E.P.

#### FURTHER EVIDENCE OF A SYSTEMIC ACTION

Further evidence has been collected about the general action of H.E.P. in that we have been able to apply H.E.P. to one of several co-existent wounds with the result that healing in the treated wound was accompanied by healing in the others. One case was of particular interest:—

Gnr. H. W. Admitted this hospital, Dec. 8, 1943. A circumcision was performed on Nov. 25. No healing was apparent in the wound, and an ulcer formed, which in the middle of December covered nearly one-third of the glans penis around the orifice of the urethra. A second ulcer formed on the place of a small scratch on the scrotum. No evidence of V.D.; Kahn negative. Treatment with sulphanilamide, eusol dressings, and hypertonic saline baths was unsuccessful. Treatment with H.E.P. was started on Jan. 8, 1944. H.E.P. was applied only on the ulcer of the scrotum. In 17 days both ulcers healed.

Owing to unforeseen circumstances the treatment with H.E.P. had to be discontinued for a fortnight. The treated wounds responded to this interruption in two ways: in the smaller group healing proceeded satisfactorily, whereas in the major group the condition retrogressed again. After the treatment was renewed an interesting fact was observed—the patients who had larger lesions responded to the first application of H.E.P. with a protein shock: shivering, rise of temperature to 104°, P.R. 140. After several applications this reaction subsided. The fact

can be explained in the way that the interruption led to an accumulation of antibodies, so that the individual treated responded with a form of anaphylactic shock.

Recently lesions caused by mustard gas have been treated with H.E.P. This work is being carried out in collaboration with the Anti-Gas Laboratories, R.E.

## OTHER CASE RECORDS

### CHRONIC ULCERS

Bacteriology in all the undermentioned cases did not show any particular features. Staphylococci were the organisms present in the majority of the lesions. Kahn was always negative.

#### A. Cases classified as Successful.—

*Case 1.*—Bdr. W. M. T. Admitted this hospital, Dec. 8, 1943. Suffered abrasion in October, 1943. On this place over anterior aspect of lower third of tibia an ulcer formed. Treatment with acriflavine, eusol, sulphanilamide, and sodium sulphate was unsuccessful. The ulcer increased gradually in size until it occupied an area of 35 sq. cm. All characteristics of an indolent ulcer were present, undermined and indurated edges and a floor without sign of active granulations. After 120 days of unsuccessful treatment, the ulcer healed after 35 days under H.E.P. apart from a small area measuring 0.25 sq. cm., which broke down repeatedly before it eventually healed.

*Case 2.*—Civ. Att. H. A. Admitted this hospital, March 3, 1944. Wounded in 1940 by bomb splinter. Deep laceration of dorsum of toe and traumatic amputation of big toe. After a prolonged recovery the wound healed. A minor injury in October, 1943, caused the formation of a small ulcer on the amputation stump. Treatment with acriflavine, sulphanilamide, and hypertonic saline during 12 weeks' previous treatment in this hospital was unsuccessful. The lesion, measuring 1 sq. cm., healed, after 150 days' unsuccessful treatment, in 6 days under H.E.P.

*Case 3.*—L. Cpl. S. R. S. Admitted this hospital, Dec. 8, 1943. On place of small abrasion an ulcer formed in October, 1943, over anterior aspect of left tibia. After admission to hospital suffered minor abrasion on cradle put as protection over his leg. A deep ulcer formed on this place as well. Treated with vaseline gauze, sulphanilamide, iodoform without success. Both ulcers, measuring together 38 sq. cm., healed in 45 days under H.E.P. The ulcer on the right leg broke down after a violent knock on the scar. Treatment with sodium sulphate was unsuccessful. Lack of H.E.P. allowed renewal of treatment only after an interval of three weeks. During this period the ulcer had reached the size of 25 sq. cm. The effect of H.E.P. treatment was again successful. The ulcer healed this second time in 28 days.

*Case 4.*—Pte. A. C. Admitted this hospital, Nov. 30, 1943. Injured leg at end of August. The abrasion became inflamed and an ulcer developed. Treatment consisted of sulphanilamide and tulle graft, vaseline gauze, saline dressings, and pinch-graft. The ulcer, measuring 4 sq. cm., healed, after 91 days' failure, in 33 days under H.E.P.

*Case 5.*—Gnr. L. N. Admitted this hospital, Dec. 16, 1943. On Nov. 8, on place of a small furuncle an ulcer formed on right forearm. Resisted treatment—sulphanilamide, eusol, hypertonic saline—for 49 days. The ulcer, 2 sq. cm. in size, healed in 5 days under H.E.P.

*Case 6.*—Lieut. G. L. Admitted this hospital, Dec. 8, 1943. On place of furuncle in left axilla an ulcer formed which gradually increased in size and showed no healing tendency for 60 days under treatment with acriflavine, sulphanilamide, and vaseline gauze. This ulcer, 8 sq. cm., healed in 18 days under H.E.P.

*Case 7.*—Bdr. J. S. Admitted this hospital, Nov. 30, 1943. Minor injury of left leg on Oct. 11. Treatment with sodium sulphate, vaseline gauze, saline, egg albumen, during a period of 42 days was unsuccessful. Healed in 23 days under H.E.P.

*Case 8.*—Pte. Z. L. Admitted this hospital, Feb. 23, 1944. On place of small furuncle on dorsum of left hand an ulcer formed which resisted treatment with eusol, sulphanilamide, 14 days' crude penicillin, and short waves, for a period of 49 days. The ulcer, with undermined and indurated edges, and 5 sq. cm. in size, healed in 6 days under H.E.P.

*Case 9.*—Tpr. J. T. Admitted this hospital, Nov. 27, 1943. Knocked shin at beginning of September. An extensive ulcer formed, which, in October, covered the middle third of the anterior aspect of the right leg. Treatment with sulphanilamide powder, vaseline gauze, and fixation in P.O.P. was unsuccessful. In December three other ulcers formed, two on the inner aspect of the leg below the knee and another over the calf. All the areas had the typical appearance of indolent ulcers. In 28 days all ulcers healed under H.E.P., apart from an area measuring 1 sq. cm. over the anterior aspect of the shin. Lack of H.E.P. determined the discontinuation of this treatment. The condition retrogressed and an ulcer formed also on the dorsum of the right hand. After three weeks' interval treatment with H.E.P. was renewed and the ulcers, now measuring 28 sq. cm., healed in 36 days. During the interruption of the treatment with H.E.P., dressings with hypertonic saline and eusol were applied.

*Case 10.*—A. E. F. Admitted this hospital, Dec. 8, 1943. Suffered for three years from desert sores on the right leg. Was treated with different methods in his unit without success. In hospital since September, 1943. The treatment consisted of saline dressings, application of red lotion, eusol, sodium sulphate, vaseline gauze, and sulphanilamide powder. No improvement resulted. In October, 1943, another ulcer formed on the right forearm which showed the same resistance to treatment as the ulcer of the leg. After this prolonged period of unsuccessful treatment, including 120 days' hospital treatment, H.E.P. was applied on the ulcerated area of the leg. The ulcer consisted of a whole system of minor ulcers which communicated under skin bridges. Treatment for experimental reasons was applied only on the ulcer of the leg. Healing started in all areas simultaneously, including the ulcer on the right forearm, which was covered only with a dry dressing. The ulcer healed in 45 days. The scar broke down in several minor areas on more than one occasion, but always healed rapidly under H.E.P.

**Case 11.**—Tpr. C. W. Admitted this hospital, Dec. 8, 1943. In beginning of October suffered minor abrasions on tibia. An abscess formed and was incised. No healing followed and soon an ulcer formed in this area. Treated in hospital unsuccessfully with sulphanilamide, eusol, sodium sulphate, for a period of 120 days. The ulcer measured at this time 35 sq. cm. The floor was sloughing, the edges were undermined and indurated. This ulcer diminished in size within 32 days to 2 sq. cm. Healing in this remaining area was very slow and lasted a further 32 days.

**Case 12.**—Gnr. A. S. Admitted this hospital, April 18, 1944. In August, 1943, insect bite over right olecranon. An ulcer formed which resisted treatment for 240 days. Sulphanilamide, cod-liver oil, and flavine were used for dressings. The ulcer over olecranon bursa, measuring 2 sq. cm., healed in 10 days under H.E.P.

**Case 13.**—Dvr. R. L. Admitted this hospital, March 7, 1944. Admitted to hospital suffering from essential hypertension. He had multiple xanthomata. One of these tumours was excised. The wound did not heal by first intention and showed no healing tendency for 5 weeks. Treatment consisted in sulphanilamide powder, saline baths, and saline dressings. The wound healed in 30 days under H.E.P.

**Case 14.**—Spr. H. C. Admitted this hospital, April 19, 1944. Noticed appearance of varicose veins in 1941. Ulcer on left ankle formed in April, 1943. Treated in hospital for five weeks; ulcer healed. Trendelenburg operation. Soon after discharge the ulcer broke down again. Treated in hospital for 10 weeks without success—and 15 weeks in convalescent depot. Treatment consisted of application of sulphanilamide powder, Peru balsam, vaseline gauze, eusol, and fixation in P.O.P., Lassar's paste, and vitamin oil. After one year's unsuccessful treatment the ulcer healed in 14 days under H.E.P.

**Case 15.**—Dvr. A. N. M. Admitted this hospital, April 4, 1944. Admitted with a deep ulcer over medial aspect of right knee. Soon a second ulcer formed on the calf on the place of a small furuncle. Treated with crude penicillin, Thiersch graft. After 19 days of treatment no improvement was achieved. This ulcer healed in 14 days under H.E.P.

### B. Cases classified as Failures.—

**Case 1.**—Gnr. F. K. Admitted this hospital, Dec. 8, 1943. Knocked the shin at beginning of December. A deep ulcer formed which showed no improvement after a variety of treatments. H.E.P. led to a quick improvement and after 28 days the ulcer appeared almost healed. At this time a haematoma formed in the scar and further application of H.E.P. did not seem to influence the condition.

**Case 2.**—C.P.O. G. C. Admitted this hospital, Dec. 8, 1943. In middle of September an ulcer formed on place of a small abrasion. The appearance was that of a typical indolent ulcer. Different treatments, including many weeks of treatment with H.E.P., did not seem to influence the condition.

**Case 3.**—Pte. G. C. Admitted this hospital, Dec. 8, 1943. In July an ulcer formed on the second toe of the left foot. Different methods of treatment

were unsuccessful. Sulphanilamide powder, acriflavine, sodium sulphate, and crude penicillin were used. After treatment with H.E.P. the ulcer decreased in size from 2 sq. cm. to 0.5 sq. cm., but this remaining area proved to be resistant for many weeks and the ulcer is still unhealed.

**Comments.**—Some of these case reports strongly support the view that healing and non-healing are not due to local conditions. Infection in these cases appears to be of only secondary importance. Chronic ulcers start on exposed areas like ankle and lower third of shin, but this seems to be only the expression of a general condition of 'non-healing'. Minor abrasions and small furuncles on distant parts of the body become ulcers also and show the same 'non-healing' or, if successfully treated, 'healing' tendencies. Cases 3, 9, 10, 15, and the case of Gnr. H. W. described in the main report, appear to illustrate this view. H.E.P. seems to be a substance which affects not so much the local condition, but rather the general 'tendency to heal.'

### CHRONIC WOUNDS

Klebs-Löffler bacilli were excluded in all wounds. Repeated bacteriological examinations showed staphylococci and *B. proteus* as the most common organisms.

### A. Cases classified as Successful.—

**Case 1.**—L/Sgt. P. M. Admitted this hospital, Nov. 11, 1943. On Feb. 5 wounded by bomb splinter. Perforating wound of right leg. The wound was treated mainly in P.O.P. with window and applications of sulphanilamide for long periods, with sodium sulphate, and one unsuccessful pinch-graft. After 270 days' unsuccessful treatment the wound, 10 sq. cm. in size, healed in 52 days under H.E.P.

**Case 2.**—Pte. R. C. Admitted this hospital, Dec. 2, 1943. On Sept. 24 shell wound of right ankle. Treatment by local application of sulphanilamide, vaseline gauze, saline, eusol, and egg albumen. No improvement. After 70 days' treatment the size of the wound remained unchanged—5 sq. cm. This wound healed in 48 days under H.E.P.

**Case 3.**—Pte. P. M. Admitted this hospital, Dec. 8, 1943. On April 6 shell wound of both shoulders. Treatment for 270 days with sulphanilamide, acriflavine, and hypertonic saline left open two areas on both shoulders measuring 6 sq. cm. The wounds healed in 29 days under H.E.P.

**Case 4.**—L/Cpl. W. T. Admitted this hospital, Oct. 21, 1943. Mine wound of right leg with fracture of fibula, Oct. 10. Repeated X-ray examination showed the presence of a small bone abscess. After 100 days' treatment the wound showed no improvement whatsoever. Healing of an area of 30 sq. cm. was achieved in 24 days under H.E.P., leaving only a minute sinus corresponding to the bone lesion.

**Case 5.**—Lieut. H. R. Admitted this hospital, on Dec. 8, 1943. Sept. 30, shell wound. The wound showed practically no healing for 72 days under sulphanilamide and saline dressings. Healed in 17 days under H.E.P.

*Case 6.*—Lieut. J. O'L. Admitted this hospital, Dec. 8, 1943. Shell wound of leg, Oct. 1. Treatment with acriflavine, sulphanilamide, and saline left after 105 days a wound measuring 5 sq. cm. over the anterior aspect of the tibia. The wound healed in 6 days under H.E.P.

*Case 7.*—Lieut. P. M. Admitted this hospital, Dec. 16, 1943. Road accident, Dec. 15. Compound fracture left femur. Union of fracture proceeded satisfactorily. Treatment for 73 days with sulphanilamide, eusol, and Thiersch graft left an area of 4 sq. cm. unhealed. This wound healed in 8 days under H.E.P.

*Case 8.*—Spr. W. W. Admitted this hospital, March 29, 1943. Compound fracture of radius. Small wound of dorsal aspect of forearm did not heal, apparently owing to presence of bone infection. Removal of sequestrum on Jan. 6, 1944. The wound did not heal even after this operation, and 60 days after sequestrectomy the wound was still unchanged. The wound healed in 4 days under H.E.P.

The following two cases are included in this series as successes in spite of the fact that healing was not complete when the patients were evacuated to U.K.—but the wounds showed such good progress that eventual healing appeared to be almost certain.

*Case 9.*—Bdr. W. M. Admitted this hospital, Oct. 21, 1943. Multiple mine wounds on Aug. 9. Severe bone injury of left hip. Apart from this injury, for which the patient was invalided to U.K., there were three wounds present, two on the right flank and one on the right arm, measuring together 50 sq. cm. These wounds did not show any 'healing tendency' for 160 days. The wounds reduced in size to 14 sq. cm. in 41 days under H.E.P. At this time the patient was evacuated to U.K.

*Case 10.*—Spr. F. B. Admitted this hospital, Jan. 18, 1944. Car accident on Oct. 3, 1943. Compound fracture of right ankle. Ankylosis of ankle followed. Treated in P.O.P. with window. The wound present over the right ankle healed only very slowly. Treatment with sulphanilamide, eusol, saline, and one pinch-graft left after 181 days an unhealed area measuring 5 sq. cm. When the patient was evacuated to U.K., 30 days after the commencement of treatment with H.E.P., the wound, surrounded by extremely adherent scar tissue, was reduced to 1.5 sq. cm.

### B. Case classified as a Failure.—

*Case 1.*—F. N. Admitted this hospital, June 6, 1943. On April 5 shell wound of right thigh and compound fracture of tibia. Union of the fracture was achieved, but the wound in the popliteal fossa did not heal. The wound healed under treatment with H.E.P. from 20 sq. cm. to 3 sq. cm., but broke down at this stage repeatedly. For one month the patient was again treated by fixation in P.O.P. On removal of the plaster the wound was bigger than ever. H.E.P. was applied again and this time it seems that final healing will result. This case is nevertheless classified as a failure as the delay in final healing was too long.

**Comments.**—Wounds due to major injuries, mainly projectiles, sometimes acquire after a certain period the appearance of chronic ulcers.

These cases seem to present the same problem as the chronic ulcer. In another group the position of the wound—adhesions to muscles, tendons, or bones—causes the main delay in healing. Fixation in P.O.P. or grafting does not appear to have any influence in some of these cases. The action of H.E.P. seems to favour the 'healing tendency' against the locally conditioned 'breakdown tendencies', due to tension, etc. The normal rate of healing is not apparently sufficient to achieve this result. H.E.P. seems to turn the balance in favour of the constructive processes.

### CHRONIC BURNS

Bacteriological examinations showed a variety of organisms. Healing and non-healing again did not seem to have any correlation with particular bacteriological findings.

*Case 1.*—Gnr. H. C. Admitted this hospital, Dec. 8, 1943. Suffered accidental petrol burns in October. Most of the burns healed quickly apart from some areas where healing was extremely delayed. An area of 5 sq. cm. on the left calf did not show any healing progress for 49 days. This area healed in 21 days under H.E.P.

*Case 2.*—Gnr. P. H. Admitted this hospital, Dec. 8, 1943. On Oct. 11 suffered accidental petrol burns of right leg and thigh. Treatment with sulphanilamide powder, tulle gras, and saline left an unhealed area after 100 days which showed no decrease in size for 42 days. The area of 10 sq. cm. on the inner aspect of the right thigh healed under H.E.P. in 21 days.

*Case 3.*—Gnr. J. W. Admitted this hospital, Dec. 16, 1943. Suffered accidental petrol burns on Nov. 21. Treatment with sulphanilamide powder, tulle gras, and saline dressings left an unhealed area 30 sq. cm. in size which showed no progress whatsoever for 42 days. This area healed in 32 days under treatment with H.E.P.

*Case 4.*—Cfn. S. W. Admitted this hospital, Dec. 24, 1943. Suffered accidental petrol burns on Nov. 22. An area of 50 sq. cm. showed no progress whatsoever for 45 days. This area healed in 14 days under H.E.P.

*Case 5.*—L/Cpl. F. H. Admitted this hospital, March 8, 1943. Suffered accidental burns of face. An area below the left eye showed after three weeks' treatment the appearance of a chronic indolent wound. In this case H.E.P. was applied at this period because it appeared important to achieve quick epithelialization to avoid contracture of the eyelid. The wound healed in 4 days under H.E.P. This case is included as a success in spite of the fact that experimental restrictions of at least 6 weeks' indolence were not observed.

*Case 6.*—Gnr. W. M. Admitted this hospital, March 5, 1944. Suffered extensive petrol burns in October, 1943. Treatment with grafts and sulphanilamide left some areas measuring 4 sq. cm. which did not show any healing progress for 75 days. These areas healed in 6 days under treatment with H.E.P.

*Case 7.*—Cfn. B.-J. Admitted this hospital, Nov. 11, 1943. Suffered severe petrol burns of



hands and legs on Jan. 6. The burns of the right thigh and leg were extremely severe. The loss of skin in these areas was complete. Treatment with sulphanilamide and tulle gras and saline baths did not achieve any result. Several Thiersch grafts and pinch-grafts failed. The general condition of the patient deteriorated and he required repeated blood transfusions. In October H.E.P. was applied on the extensive raw area of the thigh and right leg. The response was almost immediate. Epithelialization started from all edges and all the following grafts took 100 per cent. The patient's burns were practically healed by the beginning of February, 1944. Minor areas in the extensive scar tissue broke down occasionally, but healed quickly under H.E.P. The patient left the hospital with almost full range of movements in hip- and knee-joints. This case illustrates very well the postulate put forward in the previous report that the take of grafts depends largely on the 'healing tendency' of the wounded area.

*Case 8.*—P.O.W. (Italian) J. B. Admitted to this hospital, on April 29, 1944. This case is included in the series in spite of the fact that his burns are not yet healed. He suffered accidental petrol burns on April 9, 1944. He was treated with sulphanilamide and tulle gras. The extensive burned areas on both thighs and legs were septic. The patient's general condition deteriorated gradually and the burns showed not the slightest healing

tendency. The granulations were oedematous and multiple hæmatomas were present at each change of dressings. At this time, 42 days after the accident, when his local and general condition became daily worse, H.E.P. was applied. The result was almost immediate. His temperature dropped to normal, his mental outlook improved rapidly, and the appearance of the burns underwent an extraordinary change. They became flat and healing started from all edges and from small scattered epithelial islands. Within a fortnight the area decreased in size by a half. This case illustrated the postulate that the augmentation of the tendency to heal by growth-stimulating substances may lead to an improvement in the general condition.

**Comments.**—The experiences in chronic burns appear to justify the trial of H.E.P. on fresh burns. The final result in the treatment of burns depends largely on the balance of local sepsis and healing tendency, especially in the first stages. Therapeutic trials of fresh burns with H.E.P., not included in this series, appear to support this view. From a purely experimental point of view it will be difficult to assess these results. The results of chronic burns and the difficulty in dealing with burns where the balance has been turned in favour of the destructive processes, appear to justify such a trial.

## FRACTURE-DISLOCATION OF THE OCCIPITAL BONE

By SELWYN TAYLOR, SURGEON LT.-COMMANDER, R.N.V.R.

"TRUE localized fractures", states the late Wilfred Trotter (1932), writing of the skull, "are not usually accompanied by much evidence of concussion or other general cerebral disturbance". To what length this is possible is illustrated by the following case report.

### CASE REPORT

**HISTORY.**—J. G., a seaman aged 31, was returning from shore leave on April 12, 1944, when he fell a distance of 9 ft. in the black-out from the boat deck to the main deck of a trawler which he had to cross in order to reach his own ship. He fell headlong and struck the back of his skull on the edge of a small coal locker constructed of mild steel plate  $\frac{1}{4}$ -in. thick. The quartermaster was standing only a few feet away at the time, and he stepped forward with a torch to find out what had happened. He found the seaman sitting on the deck quite alert and not dazed, searching for his upper denture which had fallen out of his mouth; the lower one, though slightly damaged, was still in place. There was plenty of blood about and he summoned an ambulance which arrived within five minutes and carried the man to Sick Quarters on a stretcher after a bandage had been applied to his head by the Sick Berth attendant.

**ON EXAMINATION.**—He was not shocked or concussed, nor had he any other disability beyond a fairly straight 6-in. laceration of the scalp horizontally across the external occipital protuberance. He was therefore taken straight to the operating theatre and

placed face down on the table, an improvised head-rest being made of sand-bags and pillows.

**OPERATION.**—The scalp was shaved for an area about 3 in. beyond the wound and the skin cleansed with C.T.A.B.; this proved remarkably efficient

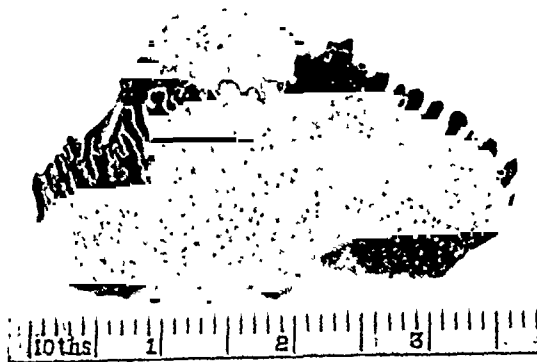


FIG. 461.—Avulsed fragment of skull.

for removing matted blood, grease, and dirt from the hair. Novutox, 2 per cent, was infiltrated all around the laceration, the skin edges were then excised very narrowly and bleeding temporarily arrested by mosquito clips on the galea aponeurotica, and small pieces of grey paint were lifted out of the wound. It

was only at this stage that the full extent of the injury became apparent.

An irregular area of the skull was missing, measuring about 4 by 2½ in., and at the lower edge of the wound the bone was seen to be double banked, suggesting that the missing piece of occiput had been driven downwards like a shutter between the dura and the intact bone. The bone, which was the upper squamous part of the occipital, had been avulsed at the occipito-parietal suture on each side.

each of sodium bromide and chloral he was soon asleep. Eight hours later he was started on a course of sulphadiazine, 2 g. being given four-hourly.

Meanwhile a messenger had arrived from the ship with a box containing what the captain described as "a small piece of material found in the scuppers,

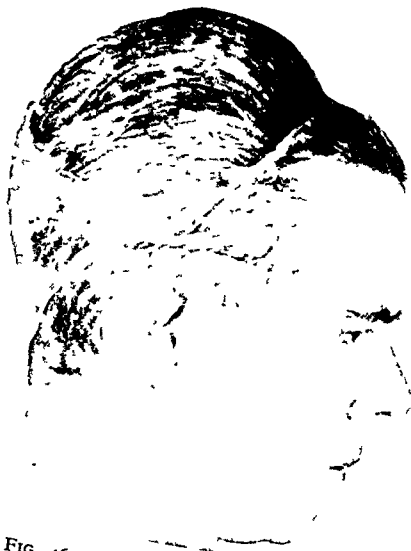


FIG. 462.—Perspex splint in position.



FIG. 463.—Wound after three weeks.

the deck had been washed down before search was made". It proved to be the missing portion of the skull (Fig. 461).



FIG. 464.—Lateral radiograph of skull.

Fig. 461 the lambda is seen at the upper part of photograph and a small part of the left parietal remained attached at the occipito-parietal articulation. It is noteworthy that the torcular Herophili escaped undamaged. The dura had not been punctured; this was remarkable, as the impacted fragments were covered with sharp spicules. The bone lying between the intact skull and the dura was gently levered out piecemeal, and it was seen to be only a small part of the total area missing. The soiled bone edges were nibbled away with Stille rongeur forceps and the tissues repeatedly irrigated with 1-1000 euflavine in normal saline; the wound had to be extended at each end to give good access to the bone. It was now 2 a.m. and it seemed probable that there must be a piece of bone lying in the ship; a signal was therefore made requesting a search at the site of the accident.

The bone and scalp edges were dusted with sulphonamide powder and the latter were sutured with two layers with Chinese twist silk. A dry dressing was applied and secured with a crepe bandage. The patient was returned to the ward in excellent condition, his only complaint being a little puffiness of the eyelids from having to spend over an hour lying on his face. He was propped up in bed and a careful clinical examination made of his central nervous system. Biceps, supinator, patellar, and ankle reflexes were all present normally and equally on both sides. Only the left lower abdominal reflex could be elicited. Eye movements were full and the visual fields by rough measurement undiminished. The plantar reflexes were both flexor. After 15 gr.

PROGRESS.—Convalescence was uneventful. Alternate stitches were removed on the third day and the wound was clearly healing by first intention. The following day Surgeon Captain Lambert Rogers, Consultant in Neurosurgery, flew over to see the

patient. He suggested that as the patient felt so well sitting up in bed he might be allowed to sit up in a chair, and this was instituted the next day. The patient was got up gradually over a fortnight and made to bend his head down between his legs when sitting to restore his vasomotor tone. Whether or not this was of any use he certainly never suffered from any dizziness or headache and was allowed to go ashore by himself at the end of this period. Whilst lying in bed he discovered that when he tried to read the print below a poster on the wall opposite there was difficulty in seeing all the letters in the visual field at one time, but that if he focused farther along the line he could fill in the missing letters. Facilities for accurate mapping of his visual fields were not available, but it seemed clear that he had a scotoma and this could be explained by direct trauma to the occipital area of the brain. The lesion became progressively less but had not entirely disappeared at the time of his discharge from Sick Quarters.

The scalp pulsed over the area previously occupied by the external occipital protuberance, and it was therefore necessary to give him some protection so that he could lean back without injury to himself. The Senior Dental Officer, Surgeon Lieutenant-Commander C. Ellison, R.N.V.R., took an impression of the back of the patient's head in 'Alston impression

compound'; on this was sketched a suitably sized obturator in indelible pencil. This was cast in plaster-of-Paris, and from a sheet of  $\frac{1}{8}$ -in. Perspex, obtained from the nearby naval air station, a splint was made which had retaining side pieces over the ears rather like a pair of spectacles in reverse (Fig. 462). The patient was discharged three weeks after the accident and recommended for shore service only until it is considered that bone-grafting can be carried out without undue risk of stirring up old infection (Figs. 463, 464).

I wish to record my debt to Surgeon Lieutenant-Commander C. Ellison, R.N.V.R., for his help and skill in constructing the Perspex splint; to S.B.P.O. G. A. Bowyer for assistance at the operation; and to the dental mechanic, S.B.P.O. L. A. Brown. Last, but not least, I am indebted to Sub-Lieutenant Kay, photographic officer at a Royal Naval Air Station, for the illustrations.

#### REFERENCE

TROTTER, WILFRED (1932), *A System of Surgery* (ed. C. C. Choyce), 3. London.

## A URETERIC CALCULUS OF UNUSUAL SIZE

By GEORGE MARANGOS AND G. E. PORTER

FROM THE GOVERNMENT DISTRICT HOSPITAL, LIMASSOL, CYPRUS

USUALLY ureteric calculi are small, their size varying from that of a pea to a date-stone, their length seldom exceeding 2 cm. Bigger ones are very occasionally seen, but the stone upon which we are about to report is surely a rarity.

### CASE REPORT

**HISTORY.**—The patient was a Cypriot man, aged 48, who had always enjoyed excellent health until some 7 years previously, when he was involved in a motor-car accident and sustained a fracture of the left side of the pelvis and a ruptured posterior urethra. He was operated on immediately. The urethra was sutured and suprapubic drainage was performed. He left the hospital cured after 50 days.

Six months later he suffered from colicky pains in the left iliac fossa. On several occasions he passed blood and pus per urethram. He also had high fever and rigors. He was treated by several doctors with urinary antiseptics.

Last year the signs and symptoms increased and the fever was more prevalent. The patient had become pale and wasted and suffered from anorexia. Four months before coming to the hospital the doctor who was attending him at that time had taken a radiograph. Here is the report: "In the left side of the pelvic cavity a long opaque shadow has been found. This is not likely to be a dilated ureter or a ureterocele, but belongs very probably to a foreign body, probably a drainage tube."

Two months later the patient came with his doctor in order to have the "foreign body" removed.

**ON EXAMINATION.**—He was a thin pale man. His heart and lungs were normal, B.P. 160/80. There was a midline scar following suprapubic

drainage. In the left iliac fossa there was slight tenderness; deep palpation gave the impression of a long fixed solid lump. The left kidney was enlarged and tender, the right kidney normal. The posterior urethra had a step stricture of an advanced degree.

#### Urine Examination.—

Albumin . . . Sugar, nil.

Microscopical: Leucocytes, positive; R.B.C., positive.

Taking into consideration the shape and position of this lump, the clinical and X-ray examination showed it to be a calculus rather than a foreign body. A cystoscopy would have cleared up the situation, but unfortunately in spite of persistent dilatation the urethra was never stretched sufficiently to pass the instrument. An intravenous pyelogram (Fig. 465) showed a normal condition on the right, and on the left there was no excretion of dye into either the ureter or the kidney.

**OPERATION.**—Under the diagnosis of ureteric calculus we operated in November, 1941, under ether anaesthesia.

An incision in the left iliac region was made 8 in. long, extending from the anterior superior spine to the anterior inferior spine. After separating the muscles the peritoneum was pushed medially and the ureter was easily found. It was very dilated, very thick, and fixed firmly in the inflamed surrounding tissues, so that it was impossible to mobilize it. The ureter was opened over the calculus, which had to be broken in order to extract it in two pieces. Proximal to the stone there was some pus, but no urine.

Although the intravenous pyelogram showed no function in the left kidney, this organ was left to be

removed at a future operation on account of the very serious condition of the patient. The ureter was sutured and the wound was drained. The extracted stone measured 6 in. in length (Fig. 466), and the chemical examination showed earthy phosphate.

drainage tube from the previous operation. But the shape, the position, and the non-function of the left kidney left no doubt that it must be a calculus. It would not be improbable to consider the large size of this stone to be due to the previous fracture of



FIG. 465.—Intravenous pyelogram 25 minutes after injection.



FIG. 466.—The extracted stone. ( $\times 3$ .)

**PROGRESS.**—The post-operative course was normal, and the patient left hospital after four weeks fully recovered. Re-examination in March, 1942, and in July, 1944, showed the condition to be very satisfactory; intravenous pyelography on both occasions showed no function of the left kidney. He has put on 15 kg. in weight and refuses the proposed nephrectomy.

**Conclusion.**—The size of the stone was so unusual that it was suggested that it might be an old

the left side of the pelvis, which involved the urethra and very probably the left ureter.

### SUMMARY

A report is given of a case of ureteric calculus of uncommon size which was operated on successfully.

## VISITS TO WAR CLINICS

### THE CANADIAN NEUROSURGICAL CENTRE, HACKWOOD PARK, BASINGSTOKE

DIRECTLY after the outbreak of war the Canadian Army Medical Service decided to send a neurological unit overseas, fully equipped not only for surgery but for medical work and for psychiatry. It was to draw its staff chiefly from the neurological services of Montreal and Toronto, since these two centres contained the two largest plexuses of neurologists in the Dominion. Interest and activity in the treatment of nervous diseases had spread through Winnipeg and Edmonton westwards to Vancouver on the Pacific Coast, but the newer loci were as yet too thinly held to be able to

contribute to the overseas unit without damage to the care of the troops training at home, to the civil population, and finally to the returning wounded soldier. Even as it was, the strain on the neurological resources of Canada proved considerable, and in spite of relief exchanges the various neurological specialties have had trying times at home and over here. They have not been alone in this. The war caught neurosurgery in particular at a half-stage of its development, and because of the length of time required for training in neurology and the peremptory

demands of the personnel committees there has been a sharp falling off in disciples rather than the required increase. The purpose of these remarks is to indicate that the overseas Canadian unit has not been furnished without increasing the shortage at home, but their fine performance here has been an ample reward.

The First Canadian Neurological Hospital was planned first as a semi-static unit. It was superbly equipped materially, and under the

was then changed to that of Canadian Neurological and Plastic Hospital.

The hospital staff arrived in batches of various sizes in the Spring and after of 1940, when the Atlantic crossing was a hazard indeed, and it cannot be gainsaid that the first year and more that followed the disappointment of hopes of immediate action proved to be a trying time. Everyone well remembers the days of the threat of invasion, when the Canadians were in the first



Col. Colin Russell.



Lt.-Col. W. V. Cone.



Lt.-Col. E. H. Botterell.

spell of Lt.-Col. W. V. Cone's persuasiveness the hospital came overseas with more luxurious and expensive hospital furniture than surely ever went to war since Hannibal crossed the Alps. The idea was none the less fundamentally sound, that since improved fittings were become almost the birthright of the civilian there was every reason why they should be given to the soldier who defended him. Armed thus, the hospital proceeded overseas with Lt.-Col., later Col., Colin Russell, of the Montreal Neurological Institute, in charge of the Medical Division (with Major, later Lt.-Col., Hyland and Captain Richardson, from the Toronto General Hospital, as his aides), and Lt.-Col. W. V. Cone, of the Montreal Neurological Institute (with Major, later Lt.-Col., E. H. Botterell, of the Toronto General Hospital, and Captain O. W. Stewart, Montreal N.I., as his right-hand men) in charge of the Surgical Division.

With the advice of Dr. Gordon Holmes and others the site that the hospital has since occupied was chosen—Lord Camrose's house at Hackwood Park, Basingstoke. Those who have followed the development of the Hospital on this lovely site have seen many changes, as expansion demanded that the hospital should break out of the house and spread into a multitude of huts behind it. Time has finally brought a further alteration, because in 1943 a Plastic Unit of some size was added. This proved, as we shall learn, to be an invaluable partnership. The name of the hospital

line of our Southern defences. And when that threat halted and became a diminishing probability it was but natural that it was succeeded by a reaction. We shall not forget the unselfishness and devotion of this volunteer force (where the voluntary part was for traffic in one direction only) and the doctors who accompanied them, nor wonder at a homesickness to which our own troops overseas are no less subject.

The first years were spent in the perfecting of a plan for the treatment of closed or blunt head injuries, for, apart from these, surgical admissions were at a low level. Lt.-Col. Cone showed particular enterprise in the management of compound fractures of the skull involving the frontal sinuses. Those with a lacerated wound across the forehead, severe bleeding from one or both nostrils, and X-ray evidence of fracture line involving both walls of the frontal sinuses were this especial field. This type of injury was at one time in this war very common in motor-cycle dispatch riders, and indeed was not often seen in others. If a frontal flap is turned down the amount of anterior basal damage usually greatly exceeds that seen on the skull films, with great comminution not only of the frontal sinuses but of the ethmoids as well, with tears in the dura and pulped brain tissue plugging the holes and even protruding into the remains of the sinuses. Lt.-Col. Cone attacked these, exenterating the sinuses, sucking out damaged brain, and patching

the dura with fascia. (Cone has not published his large series of cases.) The radicalness of his operating provoked discussion and finally emulation. This important work, together with that on penetrating wounds of the sinuses by missiles, was carried on by the Neurosurgical Service. Another interesting innovation was Cone's practice of performing a lumbar puncture at the time of dressing a cerebral abscess. When some 20 to 30 c.c. of cerebrospinal fluid are drawn off the walls of the abscess open up, and it is possible with suction and a good light to see the granulation-lined cavity in its full extent, and thus to replace a tube with certainty. The development of the head injury service was carried further with great vigour by Lt.-Col. E. H. Botterell, who succeeded to the surgical charge of the hospital when Lt.-Col. Cone returned to Montreal in the autumn of 1941. By that time the system of notification of head injuries introduced by the E.M.S. had become well established, and the Canadian Hospital sent out ambulances with surgeons to remove Canadian troops from the far distant hospitals to which many of them were first admitted. It must be confessed that these activities were regarded at times by the more conventionally-minded with some alarm. However, Lt.-Col. Botterell and his Canadians did much to prove that head injuries can be moved at any stage after injury and that it is a sensible thing to do if the transfer brings the patient into a milieu of highly-trained staff. The insistence of Lt.-Col. Botterell on the great advantages of nursing the unconscious man on his side (and in rare instances even on his face, the head being supported in a special Cone's head-rest beyond the end of the bed), and on the water and protein requirements of such men, was an object lesson. The use of the Ryle tube and the giving through it of the high caloric intake worked out by their dietitian, Bertie Finlayson, saved many lives. It was no uncommon feat for the Canadian Neurological Hospital to bring about recovery in what came to be called the "brain-stem group of closed head injuries" after periods of unconsciousness running into many days or even weeks. Botterell did great work in proving that a Head Centre has something to offer in the care of closed head injuries, raising the level to something scarcely attained elsewhere. It was from amongst these intensively studied cases that the interesting association of some subdural hæatomas with *contre-coup* injuries was discovered, a work still to be published. The hospital received the fullest support from Col. Macfarlane, Consultant in Surgery to the R.C.A.M.C. overseas, in a campaign for the better treatment of head injuries. The excellence of the service rendered was made easier by the very great help given by the radiological services. The Canadians have been fortunate in having first Major Childe (Neurological Institute, Montreal) and later Major Eaglesham (Montreal) in charge of the X-ray Department. The advantages of having a

service of this kind, able to devote the whole of its time and thinking to neurological problems, brought impressive results. This has been so not only in the period so far discussed, but later in the true battle casualty era, as was witnessed by Major Eaglesham's remarkable series of films showing air within the skull as an occurrence not only much more frequent than was supposed in the ordinary head injury, but in brain wounds caused by missiles.

During the worst of the bombing of Britain the hospital acted by a special arrangement for the E.M.S., receiving casualties from a large area and helping with the civilian neuro-surgery of the district at a time when its normal outlets were impeded.

The Dieppe raid in 1943 and, to a less extent, the hard period of training with live ammunition brought the hospital its first real experience of gunshot wounds. During a few months they treated 27 penetrating wounds of the head with laceration of the brain, with 1 death. This seemed to those with lively recollections of the last war to be almost too good to be true, but at the same time reports had come in from British neurosurgical teams in N. Africa which suggested that performance now was destined to be much better than it had ever been before. The factors chiefly responsible were reasonably early operation, efficient suction, good lighting of the wound, and the intensive use of sulphadiazine. Lt.-Cols. Cone and Botterell had soon after their arrival conducted some animal experiments at Queen Square proving that a cavity could be made in the rabbit's brain down to and opening the ventricles, and that this could be packed with sulphapyridine without ill effect. We were later to find from Alexander in Norman Dott's Clinic that this was not true of sulphathiazole, although it can be used in sealed-off brain lacerations if there is no easy way of escape into the subarachnoid spaces or the ventricles. It has just been remarked that efficient lighting has proved a major factor of success, and we may well reflect under what handicaps our grandfathers and our forebears laboured in operating by gaslight. No wonder the optimum time for operation was day-time, and that operating theatres were built with especially large windows. We see the same plan still followed by our hospital architects, who little realize that the origin has vanished no less surely than Jamshyd. The balanced shadowless, movable stand lamp seems to be superseding the fixed ceiling lamp, and may in its turn have to give place to the mercury vapour strip-lighting that is both heatless and bactericidal.

The original plan called for the use of the unit as a special C.C.S. in a static manner. It came to be used as a static hospital. Teams were sent out as required and a series of excellent young general surgeons came to Hackwood Park for short periods for training in neurosurgery so as to take up some of the load when the battles came.

Mobile units had been available for service in the field, and they proceeded overseas in 1944 under Major Keith, who had joined the hospital from Toronto in 1942. During 1943 the Canadian Army Medical authorities decided to install the plastic unit in the hospital under Lt.-Col. Stuart Gordon, of Toronto. More huts had been built by this time and space was available. Partnership between the two specialities proved to be most valuable. There were a number of facial wounds with neurological complications where help could be well given, there were even more battle wounds where the advice of the plastic surgeons in the planning of scalp-flaps was invaluable. Sir Harold Gillies has published a brief paper on the subject, and there is no doubt that the revision in the lines most suitable for scalp excisions has been timely and welcome. However, on occasion the size of the flap that must be fashioned in order to obtain the closure and primary healing of a head wound where a piece of scalp has been blown away may be formidable, and it was a great boon that immediate consultation within the hospital walls was possible.

The following case represents a combination of neurosurgical and plastic enterprise:—

*Case 1.*—Sgm. K. S., age 23. Date of operation, Sept. 30, 1944, 23.00 hr. Date of injury: Sept. 3, 1944; high-voltage burn of scalp, skull, dura, and brain. Cranio-cerebral injury due to fall from telegraph pole.

Surgeon: Lt.-Col. E. Harry Botterell. Assistant: Capt. W. D. Stevenson. Anaesthetist: Major R. A. Gordon. Anaesthetic: Pentothal intravenously.

*Pre-operative Diagnosis.*—Cerebral abscess, left occipital lobe, containing gas.

*Post-operative Diagnosis.*—Cerebral abscess, extradural abscess and necrosis of skull secondary to high-voltage burn with infection and osteomyelitis of skull. It is apparent that there has been an extensive electrical coagulation of skull with destruction of dura, necrosis of brain, and secondary infection to produce brain abscess and osteomyelitis of skull.

*CLINICAL SUMMARY.*—On Sept. 3, 1944, this patient received a high-voltage burn to back of head, neck, and side of head, with destruction of ear, and fell off ladder, receiving a wound in left forehead and large gaping cut in right thigh. He was evacuated from France, finally arriving by air evacuation in Rookdown House Hospital from Shaftsbury. First seen Sept. 27, 1944, at Rookdown House, by Lt.-Col. Botterell, when these positive neurological findings were made: (1) Headache and vomiting; (2) Fixation nystagmus to right with photophobia; (3) Very early papilloedema; (4) Right hemianopia; and (5) Increased reflexes in right leg, but no disturbance of plantar or abdominal reflexes. Radiographs of skull were advised on the basis that the patient probably had an unrecognized depressed fracture or deep infection. Lumbar puncture should not be done.

On admission to Basingstoke Neurological and Plastic Surgery Hospital on Sept. 30, the patient was very drowsy, with three to four diopters of papilloedema. He was almost completely aphasic, with gross weakness of right face, arm, and leg.

Radiographs taken in the appropriate positions of brow-up and brow-down revealed a very large abscess

in left occipital lobe, but no changes in bone density. (See Major D. C. Eaglesham's report.)

*X-RAY REPORT (Major D. C. Eaglesham).*—There is a large collection of gas in the left hemisphere posteriorly. This contains a fluid level. By posturing, a cavity approximately  $4 \times 5.5 \times 3$  cm. is outlined. This lies in the parietal and occipital lobe. It lies 1 cm. deep to the internal table of the occipital squama adjacent to the left arm of the lambdoid



FIG. 467.—Case 1. Result of combined neuro- and plastic surgery in electric burn involving bone and brain.

suture. Its long diameter is anteroposterior. Medially it extends to within 2 cm. of the midline. The left half of the lambdoid suture is slightly widened. There is no evidence of osteomyelitis. There is no pineal shadow. The gas and fluid containing lesion is considered to be an abscess with gas-forming organisms.

*Opinion:* Left cerebral abscess containing gas. Slight diastasis of lambdoid suture.

*OPERATIVE PROCEDURE.*—A burr hole was made 2 in. along the lambdoid suture and 1 in. below that point. Extradural pus was encountered. The bone was removed in a downward direction, revealing more extradural pus and pus in the bone. With Captain Stevenson's assistance all dead bone was removed. This involved exposing dura across the sagittal sinus, the lateral sinus, and removing the outer table of the mastoid process and mastoid air cells. Finally, healthy bone, which bled readily, was encountered in all the circumference of this bone defect.

By this time the cerebral abscess was protruding through the dural defect. The dural defect was considered to result from the burn rather than from destruction of dura by the infective process. Retractors were passed through the dural defect and the walls of the abscess defined and opened. Considerable pus and gas was then encountered and the wound was lightly packed.

The exposed dura and skull were then dressed with tincture of benzoin and sulphanilamide emulsion, soaked packing, tulle gras applied to the burn, and a moist dressing applied. The patient returned to the ward in considerably improved condition over his pre-operative state.

During the course of healing of the brain abscess, the adjacent burned and granulating areas were dressed and followed by the plastic surgery service.

Twenty days after the craniotomy was done the whole area was skin-grafted by means of a dermatome graft, which was cut into stamps and applied to the granulating area. This was done on the plastic surgery service on Oct. 20.

Patient is now up and about the ward with no complaints. The wound is completely healed (see Fig. 467). The right-sided weakness has cleared; optic discs are normal, but he is left with a complete right homonymous hemianopia.

Another example of the remarkable results that can sometimes be achieved will be learned from this description of the treatment of a wounded German prisoner:—

*Case 2.*—P.O.W. Hummer, German Army.

**CLINICAL SUMMARY.**—On Aug. 18, 1944, this patient received a through-and-through gunshot wound in the right occipital region. No detailed history was available, but it was suggested by one of the Field Surgical Units through which he passed in evacuation that one of the wounds had been sutured in a German Medical Unit and that the patient was subsequently captured. He was evacuated by sea and was admitted to the C.N. and P. Hospital on Aug. 31. He was then conscious, apprehensive, and inclined to be arrogant. There was some mild stiffness of the neck and his temperature was 100.5°.

Neurological examination was essentially negative except for a complete homonymous hemianopia. There were two dirty, gaping wounds, one just above the right ear and another in the occipital region. In both the edges were everted and ringed with unhealthy-looking granulation tissue. The wound above the ear showed evidence of having been sutured previously by German surgeon. From both wounds there was a seropurulent exudate, and from the larger of the two there was also some escape of cerebrospinal fluid. Palpation of the scalp between the two wounds revealed a marked comminution of the bone beneath. X rays demonstrated this comminution and, in addition, depression and in-driven bone fragments. He was begun on sulphapyridine by mouth after an initial dose intravenously and was also started on penicillin intramuscularly.

Cultures taken from both wounds pre-operatively showed the same bacterial flora in each—namely, *B. proteus*, *Staph. aureus*, and coliform bacillus. Culture of old blood-clot and cerebral tissue at the time of operation showed the same organisms. Penicillin and sulphapyridine were continued post-operatively during the first three post-operative days. Spinal fluid showed 820 polymorphonuclear leucocytes, 60 lymphocytes, 560 red blood-cells per c.mm., with a total protein of 471 mg. per cent. These figures represent the initial spinal fluid examination pre-operatively. Culture of this fluid, however, was sterile and the spinal fluid remained sterile throughout his post-operative course. Lumbar punctures were done for the first six post-operative days as often as was necessary to maintain a normal spinal fluid pressure. (This procedure was followed because of the conviction that elevated spinal fluid pressure impedes the normal processes of healing, repair, and resistance to infection in the brain wound itself.—O. W. S.). The total number of polymorphonuclear leucocytes and lymphocytes as well as the total protein steadily decreased with a reversal of the polymorphonuclear leucocytes and lymphocytes ratio until,

on Sept. 13, the spinal fluid was normal. The pressure remained normal after the sixth post-operative day.

**OPERATION NOTE.**—Operation date: Sept. 1. Surgeon: Major O. W. Stewart. Assistant: Lieut. (N/S) Reid. Anaesthetist: Major E. H. Ainslie. Anaesthetic: S.P., N.O., O.

**Pre-operative Diagnosis.**—Through-and-through wound of occipital posterior parietal region on the right, with marked comminuted fracturing of bone and gutter wound of brain; both wounds grossly infected and cerebrospinal fluid leaking from the posterior wound.

**Post-operative Diagnosis.**—Same, with addition of large dural defect, in-driven bone fragments, and a wide opening into the lateral ventricle.

**Operation.**—Excision of both scalp wounds; reflection of scalp flap; wide débridement of damaged bone, cortex, and dura; mechanical irrigation and cleansing of wound; plugging of ventricle opening with fibrin foam; repair of dural defect with fascia lata; primary closure of scalp.

**OPERATIVE PROCEDURE.**—The scalp incision was so made as to excise both of the wounds and to join and extend them so that a scalp flap was reflected with its base towards the neck. All of the fibrinous exudate and purulent material was cleaned away and it was found that spinal fluid was leaking from a wide, gaping opening into the ventricle on the right side. A considerable amount of comminuted bone was lifted out and many in-driven fragments removed. As much of the cortex as could be seen to be devitalized and infected was removed by gentle suction and irrigation. While this was being done, a small cotton pattie was placed in the opening in the ventricle, which, by the way, had a string of choroid plexus coming out of it, acting as a sort of ventricular drain. Bone was then rongeured away for some distance about the wound until more healthy bone was reached and the dural edges were then trimmed, and we were left with a very large bone defect and a dural defect which measured about  $3\frac{1}{2} \times 5$  cm. and a large excavated brain wound, which had been débrided as thoroughly as possible, with an opening directly into the ventricle. Even though this was a two-weeks-old wound and was grossly infected, the size and extent of the wound, together with the ventricular opening, seemed to make any procedure excepting primary closure an extremely dangerous one and probably doomed to failure. It was therefore decided to deal with the wound in a manner which, before penicillin, would almost certainly have led to death, but which, in the light of our past experience, offered at least a considerable degree of hope for success. A piece of fibrin foam about 2 cm. across was taken and soaked in penicillin solution, 5000 units per c.c. This was then placed into and just past the opening into the ventricle. After this had been done, sulphanilamide powder was gently dusted over the surface of the brain wound and fascia lata was taken from the thigh and used to repair the dura, using the very finest nylon with interrupted sutures for the fascial repair (Fig. 468). Penicillin was instilled into the wound beneath the fascial patch after it had been completely closed.

Sulphanilamide was then dusted over the surface of the fascial patch and the exposed dura and bone. The scalp flap was then closed with interrupted nylon sutures in the aponeurosis and then interrupted nylon for the skin. The wound was not drained. After complete closure, penicillin was instilled beneath the scalp flap. (Fig. 469.)



The whole procedure took about 4½ hours, but the patient stood the operation extremely well and was given intrathecal penicillin at the close of the operation, plus a second injection of 50,000 units following operation. He had one injection of 50,000 units while on the operating table.

The wound healed cleanly and at no time was there any evidence of inflammation or infection, either superficially or deep. After three weeks the

A very complete analysis of their material was presented by Lt.-Col. Botterell and his team at the thirty-second meeting of the Society of British Neurological Surgeons. The Canadian hospital had been specially selected for this meeting as a tribute to their Dominion colleagues with whom such happy bonds of association had been forged. The series of



FIG. 468.—Case 2. Photograph during operation, showing bone trimmed and fascial repair of dura.

patient was up and about the ward with no complaints. The decompression was mildly excavated, soft and pulsating. There was, on discharge, about 50 per cent improvement in the original left field defect.

### BATTLE CASUALTIES

The work which the Neurosurgical Service had set out to do came to fruition with the invasion of Normandy. In point of fact the work already done had been of inestimable service, but it had been in a large degree unpredicted both in duration and in amount, for it had been largely in the field of the closed or blunt head injury. In the last war these had never been segregated. When the fighting broke out across the Channel the Canadian Neurosurgical Unit went into action with an organization thoroughly prepared and tested. As things turned out the hospital proved to have been placed in a strategically ideal situation, for it allowed them to function as a high-powered unit close behind the ports able to take their own Dominion wounded direct and British Service personnel as well. Later on, when air evacuation came in force, they were still within reasonable distance of landing-grounds and once more did a great work.

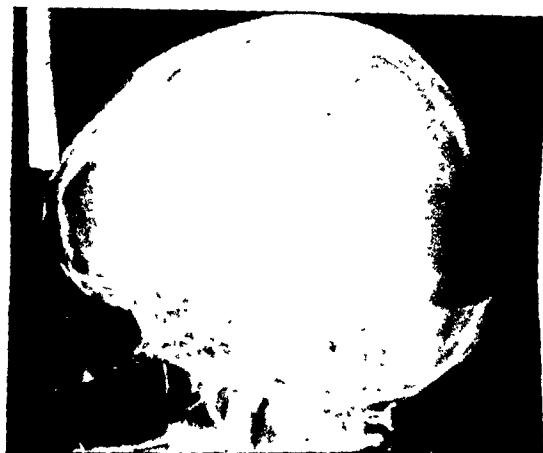


FIG. 469.—Case 2. Post-operative radiograph indicating size of wound.

papers then given is to be published separately elsewhere; it would steal their thunder to give the gist of them here. But it can be said that their over-all mortality was 4.09 per cent and that for cases with penetration of the dura and cerebral laceration the mortality was 7.6 per cent. The figures are a testimony not only to good surgery and to chemotherapy, but to excellent planning. It was no small task to admit between 20 and 50 cases a day and to keep things running smoothly. From June, 1944, to March, 1945, head injury admissions were 1134. It speaks for the highly-trained nursing services that the work went through so well. All hospitals develop an individuality of their own, a flavour, as it were, that distinguishes them. This was so at Hackwood Park. It derived in no small part from the strong personalities of the heads of divisions, who were most ably backed up by the Commanding Officers (in rotation: Col. C. E. Cross, Col. Van Ostrand, Col. R. C. Montgomery, and Col. Morley Harvie). Intense interest, hard work, a sincere desire to get to the bottom of causes of failure, and to dissect success so that it can be repeated, have been the characteristics of this Service, which none have visited without profit or left without regret.

## SHORT NOTES OF RARE OR OBSCURE CASES

## A CASE OF BENIGN PAPILLOMA OF THE URETER

By CONSTANCE M. OTTLEY

HON. SURGEON, NEW SUSSEX HOSPITAL, BRIGHTON

MALIGNANT tumours of the ureter are not very uncommon, 182 cases having been reported (Scott, 1943). Primary benign papilloma, on the contrary, is a rare condition. A search of the literature as complete as present circumstances allow has brought to light only 27 cases in which the diagnosis was verified by (1) inspection of the interior of the renal pelvis and entire ureter, and

Intravenous pycelography showed a normal left kidney and ureter. No dye was excreted by the right kidney; its outline was normal in shape and size. Two attempts at retrograde pycelography on the right side ended in failure, for the catheter could not be persuaded to pass the obstruction.

OPERATION was carried out under avertin followed by gas and oxygen anaesthesia. Because of a doubt whether the patient was fit for a one-stage operation,



FIG. 470.—Section of tumour (low power).

(2) microscopical examination of the tumour. Sixteen other reported cases have been rejected because they failed to satisfy one or both of these criteria.

## CASE REPORT

An unmarried woman of 71 complained of passing a large quantity of blood with the urine three times within the previous twelve hours and of slight aching pain in the right loin during the same period. For the last two years she had noticed an occasional smear of blood on her clothing. She had otherwise been healthy all her life apart from an attack of appendicitis a year before the present illness, for which appendectomy was performed.

Physical examination was negative. The urine contained much blood. Cystoscopy was carried out the same day. The bladder, including the ureteric orifices, appeared perfectly normal. The right ureter showed an intermittent discharge of large drops of blood, which emerged at frequent intervals with little force. On this side a ureteric catheter could be passed for 7 cm. only and provoked profuse and continuous bleeding. On the left side the catheter passed up to the kidney and withdrew clear urine.

the kidney was first removed and then, as her condition remained good, the ureter was exposed extraperitoneally. It showed a spindle-shaped enlargement about an inch long, the lower end of which was 1 cm. above the bladder. The ureter, excluding its intramural portion, was removed. The expanded part when opened was found to be occupied by a sessile mass of papillary growth encircling the entire lumen as a band 2 cm. wide. Histological examination showed the characteristic appearances of benign papilloma (Fig. 470). The kidney showed little change; the pelvis was distended, but little if at all dilated.

Recovery was delayed by partial breaking down of the lumbar wound, but was otherwise uneventful. Transurethral fulguration of the intramural part of the right ureter was carried out three weeks after operation.

The patient has been under periodic observation during the three years which have elapsed since the operation. She has remained well, with no clinical or cystoscopic evidence of recurrence.

## REFERENCE

SCOTT, W. W. (1943), *J. Urol.*, 50, 45.

## TWO CASES OF INTERNAL HERNIA

BY W. DOUGLAS PARK

SURGICAL FIRST ASSISTANT, LONDON HOSPITAL ANNEXE

THE rarity of internal herniæ justifies the publication of these cases. One case is of a well-known variety, but the second as far as I have ascertained is not a recognized entity. Happily both cases recovered from the intestinal obstruction that brought them to seek surgical treatment.

## CASE REPORTS

**Case 1.**—L. S., female aged 54 years, was admitted on Jan. 1, 1944, complaining of abdominal pain all over, but worse in the lower part. She was well until the day of admission, when she was seized with sudden severe abdominal pain. She vomited twice; the bowels remained confined.

**PREVIOUS HISTORY.**—Six years previously strangulated inguinal hernia; five years previously hysterectomy; four years previously appendicectomy and cholecystectomy.

**ON EXAMINATION.**—In obvious colicky pain. No mass could be felt, but the abdomen was tender all over, with muscle guarding. On rectal examination no abnormality was found. An enema gave no result, *feces* or *flatus*.

**AT OPERATION.**—Operation was performed approximately six hours after the onset of pain. The cæcum was distended, but not so the lower ileum. The large gut was distended up to about the mid-transverse colon, where it was found pushed up by a mass below it. This was found to be caused by a hernial sac containing about half the small gut. The small gut was easily withdrawn, with relief to the distended large gut and the obstructed jejunum leading to the sac. The sac was found to be a paraduodenal hernia or left duodenal hernia (Moynihan, 1906). While the rest of the abdomen was examined, the gut again returned into the sac, so that it was essential to close the neck. This was done with catgut sutures, picking up the peritoneum carefully so as not to injure the inferior mesenteric vein in close relation to it.

The patient made a complete recovery somewhat delayed by a mild wound sepsis. She was discharged on March 3, and when seen on May 2 was very well.

**Case 2.**—E. B., male aged 31 years, was admitted on March 31, 1944, complaining of abdominal pain. Four days before admission he had some colicky abdominal pain which subsided. Twelve hours before admission severe colicky pain started and got worse. He vomited several times and could retain nothing. The bowels had not been open and three enemata gave no *feces* or *flatus*, though he stated he felt full of wind.

**PAST HISTORY.**—He had suffered from attacks of colicky pain, wind, and constipation practically all his life. Two severe attacks six and three years ago were relieved by enemata after admission to hospital.

**ON EXAMINATION.**—He was a well-built young man, in obvious pain. The abdomen was tender all over. Rectal examination was negative.

**AT OPERATION.**—This was performed fourteen hours after the onset of pain. On opening the peritoneum the omentum presented and under this was seen small gut covered by peritoneum as if the

peritoneal cavity had not been opened. In the upper left part of the abdomen were very distended coils of jejunum which led to the right side of the abdomen under the peritoneal layer. This peritoneal layer stretched from the transverse colon to the cæcum, and it was thought to be a case of right duodenal hernia (Moynihan, 1906) into the fossa of Waldeyer, but it was found that there was no vessel in its anterior border. It was actually a double layer of peritoneum stretching from the transverse colon, then for about 2 in. along the jejunum superficial to the mesentery of the small gut, then to the terminal ileum and cæcum, which were drawn up. The edge of the fold was attached to the descending colon, thus forming an internal hernia with its mouth pointing to the left superficial to the mesentery. It contained about three-quarters of the small gut, which was also rotated through 180°. There was no strangulation, and the gut was easily withdrawn. The obstruction was actually due to a sharp kink by adhesions of a loop of small gut in the sac, but not to the sac, and when separated completely relieved the obstruction. The fold of peritoneum was easily stripped from the ileum, cæcum, and ascending colon, and remained as a double fold like an apron from the transverse colon and upper jejunum. Superficial to this was the usual apron of great omentum. The peritoneal fold was removed close to the colon. It was noted that the transverse mesocolon was very short and the ascending colon well fixed down.

The wound healed kindly and the patient made an uninterrupted recovery. He was discharged on April 21.

## DISCUSSIONS

**Case 1** is an example of a recognized internal hernia and the sac is the result of the enlargement of a fossa frequently present from birth. Lee McGregor (1943) puts the figure at 20 per cent. There is, however, no reason to suppose that this case was one of developmental origin such as Andrews (1923) suggests. Houghton (1942) quotes Brown's case as an argument against this theory, and his own case certainly did not support Andrews's observations. They were in each case, however, dealing with a hernia into Waldeyer's fossa. In my first case there had been ample opportunity for adequate exploration of the abdomen and yet no internal hernia had been noted, so that there is considerable likelihood that the occurrence was recent. In this case, as Brown (1925) found in his case, reduction was easy, but it was so easy that scarcely had one metaphorically, speaking, turned one's back before the small gut had returned to the sac as if loath to leave so snug a resting place. Repair of the opening was thus a necessity and was successfully carried out.

**Case 2**, with its history of colicky pain from childhood and the characteristically thin non-inflammatory type of peritoneal fold, appears to

be almost certainly a developmental abnormality. I have considered whether the peritoneal fold could be an abnormal arrangement of the omentum, but its complete separation from this structure, together with the fact that it extended on to the jejunum and contained no fat, make this most unlikely. Further, the omentum appeared normal. A possible explanation that I think should be considered is that the normal fixation of the colon had progressed further than usual, at the same time not being complete and leaving a fold such as was found. In favour of this is the short mesocolon with a relatively fixed transverse colon. Against it is the obvious possibility of complete fixation of the colon without any such fold. I have not found any record of a similar case, and present this case as a further example of the complex arrangement of folds and fossæ that may

result from developmental abnormality or exaggeration of a normal process, even though I am unable to give a very satisfactory explanation of how or why the hernial sac arose.

I wish to thank Mr. Butler for permission to publish these two cases and for the opportunity to undertake their treatment.

#### REFERENCES

- ANDREWS, E. (1923), *Surg., Gynec. Obstet.*, **37**, 740.  
 BROWN, F. R. (1925), *Brit. J. Surg.*, **13**, 367.  
 HOUGHTON, P. W. (1942), *Ibid.*, **29**, 360.  
 MCGREGOR, A. LEE (1943), *A Synopsis of Surgical Anatomy*, 5th ed. Bristol: John Wright & Sons.  
 MOYNIHAN, LORD (1906), *Retroperitoneal Hernia*, 2nd ed. London.

## CARCINOMA OF THE PROSTATE IN A YOUTH

By N. J. NICHOLSON

SURGEON, COUNTY INFIRMARY, LOUTH, LINGS.

THE following case of carcinoma of the prostate in a patient aged 15 is considered to be of some interest on account of the youth of the patient.

To quote Ewing (1940), "The chief age of incidence, like that of hypertrophy, is the seventh decade, when 68 per cent of the cases occur, but the disease has been observed between 40 and 50 years. Wolff (1899) collected 6 cases under 40 years, at least one of which (Billroth's, 1869) was probably true glandular carcinoma in a subject of 30 years. A rapid carcinoma with regional metastases in a youth of 17 years is reported by Gardiner and Cummins."

#### CASE REPORT

J. B., aged 15, was admitted to the Louth and District Hospital on May 3, 1943. He had had no previous illnesses, but for three months he had had straining at micturition and loss of force of the stream for three months. For these symptoms he blamed the taking of beer at a wedding. That was the first time he had taken beer. There had been slight pain on micturition, no scalding, and no discharge. He concealed the symptoms from his mother, but she took him to see Dr. A. H. Russell on account of loss of appetite, loss of energy, swelling of the ankles and face, and pallor. He was admitted on account of these symptoms.

Two days later, on May 5, he developed retention of urine. The writer saw him then. The bladder was greatly distended, reaching almost to the umbilicus. There was no evidence of disease of the central nervous system. This was confirmed by Dr. J. W. Brown, of Grimsby. After the administration of morphine sulphate gr.  $\frac{1}{4}$  and the local instillation of 4 per cent cocaine hydrochloride, an attempt was made to pass a catheter. This was not successful. Under a general anæsthetic a red rubber catheter was able to be passed easily and 24 oz. of urine were withdrawn. Rectal examination, with the bladder

empty, disclosed a hard nodular prostate with projections towards the rectum. An indwelling catheter was left in situ.

On May 9 it was necessary to reduce a paraphimosis under gas and oxygen. Anæmia was

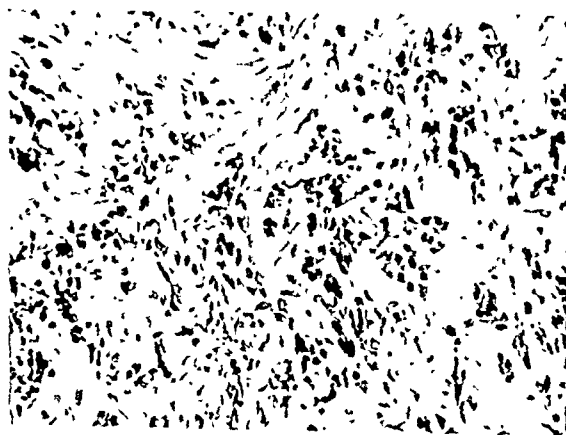


FIG. 471.—Photomicrograph made from section of piece of prostate removed at operation ( $\times 133$ ).

becoming a prominent feature of the case, and on May 13 and May 16 blood transfusions were given. Iron was given by the mouth also.

On May 20 an attempt was made to cystoscope the patient, but it was not possible to make the cystoscope enter the bladder. Under a general anæsthetic suprapubic cystostomy was performed. A large hard nodular craggy swelling of the prostate was present. The total size was about that of a tennis ball. A portion was removed for microscopical examination. The cut surface had the appearance of an unripe pear. The bladder capacity appeared only about 2 oz. Bleeding was fairly free. The incision was closed.

about a Marion's tube. The patient died the following day.

The Clinical Research Association reported that the section showed fibrous tissue infiltrated with a typical cellular carcinoma and covered by slough, "in spite of the patient's reputed youth".

On May 10 a blood-count by the Clinical Research Association gave, among other facts, the following: Haemoglobin 35 per cent, R.B.C. 2,100,000.

The red cells showed marked anisocytosis, poikilocytosis, and polychromasia. No nucleated red forms were found. The mean cell diameter was  $7.1\mu$ . There was no evidence of leukæmia.

Urinary examinations were made on several occasions by the Bruce Laboratory at the Grimsby and District Hospital. Small amounts of albumin were found and a few red blood-corpuscles. Some uric acid crystals were present. Cultures were sterile.

On May 12 the blood-urea was only 20 mg. per cent. The report on the cerebrospinal fluid was as follows: 4 c.c. clear, colourless cerebrospinal fluid. Less than 1 W.B.C. per c.mm. Protein 35 mg. per cent. Chlorides 700 mg. per cent as NaCl. Culture—no pathogenic organisms.

The blood Wassermann reaction was negative.

An intravenous urogram, on May 12, showed a slight degree of bilateral hydronephrosis, more marked on the left side. A plain radiograph of the abdomen and pelvis disclosed nothing abnormal. There was

no clinical or X-ray evidence at any time of secondary deposits in bone. No post-mortem examination was made.

In the case described by Gardiner and Cummins (1912), of San Francisco, the history was somewhat shorter, namely seven weeks. The symptoms had been colicky pains in the lower left abdomen and vomiting. The pain radiated to the left testicle. There was incontinence of urine and no hæmaturia. Later, the pain shifted to the right side of the abdomen and radiated to the right testicle. In their case there were secondaries in the retroperitoneal lymph-nodes.

I am indebted to the Clinical Research Association for the photomicrograph.

## REFERENCES

- BILLROTH, T. A. (1869), *Langenbeck's Arch. Chir.*, 10, 548.  
 — (1871), *Chir. klin. Wien.*, 76.  
 EWING, J. (1940), *Neoplastic Diseases: A Treatise on Tumours*, 844.  
 GARDINER and CUMMINS (1912), *Jour. Amer. med. Ass.*, 58, 1282.  
 WOLFF, (1899-1900), *Dtsch. Z. Chir.*, 53, 126.

## DISLOCATION OF THE CUBOID

By ALEXANDER MITCHELL

### CASE REPORT

Squadron-Leader A. H., while walking on rough ground on Aug. 23, 1941, twisted his right foot, which became very painful and useless.



FIG. 472.—Radiographs: A, before, and B, after, manipulation.

On examination a few hours later the dorsum of the foot was swollen and tender and there was a peculiar indrawn appearance of the skin just proximal to the base of the fifth metatarsal bone. Radiography showed the condition to be that of dislocation of the cuboid inwards and upwards. While the displacement is evident in the antero-posterior picture, the only thing to be seen in the lateral one is very slight displacement of the cuboid with overlapping of its shadow by that of the fifth metatarsal.

On manipulation under anæsthetic it appeared that the attachments between the cuboid and the fifth metatarsal had been completely rent asunder. Reduction was easily accomplished and after several weeks' fixation in plaster restoration of function was complete and has remained so.

Fig. 472, A shows the foot before, and B after, manipulation.

There is not a reference to this dislocation in any of the literature at present at my disposal.

My thanks are due to Surgeon Rear-Admiral Hull for permission to use the radiographs taken by his staff.

## A CONSERVATIVE OPERATION FOR SEVERE HAND INJURY

By GEORGE A. POLLOCK

SURGEON L.M.S., DEPARTMENT OF HEALTH FOR SCOTLAND

AMPUTATION at the site of election is a simple method of dealing with a severely lacerated limb. When treated in this manner, the patient can usually be assured of a rapid, uneventful convalescence and of an early discharge from hospital. The provision of a suitable prosthesis subsequently will permit, in suitable cases, of an early return to some form of gainful employment.

in addition to which the associated metacarpal bones were fractured. The fifth metacarpo-phalangeal segment was intact except for a compound fracture of the proximal phalanx of this finger. Multiple metallic bodies were seen lying in the palm.

The lacerations were so extensive that one's first reaction was to amputate through the lower third of the forearm, but on second thoughts a more conservative procedure was adopted. The metacarpal



FIGS. 473-475.—Photographs, taken seven months after injury, showing the usefulness of the 'hand'.

The simplicity of procedure and the straightforward nature of the subsequent phases of treatment recommend this method. Simplicity and rapidity, however, is not the answer to this problem. Our objective is not to show a rapid turnover of a large number of permanently crippled men. Our aim is to treat each case as an individual problem so that at the time of discharge from hospital our patients will possess limbs as completely sound functionally and anatomically as it lies in our power to make them. It must be realized that the possession of a natural limb, even although somewhat impaired in function, is preferable usually to a prosthesis. No pain should be spared to conserve as much of a member as is functionally useful, even though the immediate surgical procedure is more difficult or the subsequent period of convalescence more prolonged. The technical steps may be more difficult and the convalescence more prolonged, but the result, when successful, is well worth the additional amount of effort expended. That conservatism is well worth while is demonstrated in the following case.

## CASE REPORT

J. S. was admitted to an E.M.S. hospital on June 29, 1943, with extensive lacerations of the left hand, face, and abdomen, which had occurred as the result of the accidental explosion of a faulty mortar fuse. The skin and soft tissues of the dorsal and palmar aspects of the hand were extensively destroyed. A traumatic amputation of the thumb had occurred at the metacarpo-phalangeal joint. The index, middle, and ring fingers were also missing at the same level,

bones of the index, middle, and ring fingers were removed at the carpo-metacarpal joints. This permitted re-grouping of the remaining interosseal muscles in equal proportions round the first and



Fig. 476.—Radiographs of the 'hand'.

fifth metacarpal bones. It was then possible partially to cover the base of the first metacarpal bone and its re-grouped muscles with skin. The lacerations of the fifth finger were sutured, and the 'two-finger stump' so formed was surrounded with vaseline gauze dressing and fixed in plaster-of-Paris. Dressings were carried out at ten-day intervals, and on each occasion the 'two digits' were approximated towards each other so that the intervening gap was reduced in size.

# THE BRITISH JOURNAL OF SURGERY

On Oct. 27 the little finger was amputated through the centre of the middle phalanx, as it was felt that this would give a more controlled 'pincer movement'. Occupational therapy and physiotherapy were begun ten days later.

The patient was both co-operative and intelligent and, as the accompanying photographs show, has made excellent progress. At the time of his discharge on Feb. 3, 1944 (roughly seven months after his injury)

he can write, use a knife and fork (*Fig. 473*), work with a chisel (*Fig. 474*), or raise a cup to his mouth (*Fig. 475*). His grip is good and he has got a useful 'hand' (*Fig. 476*).

I wish to express my thanks to the Department of Health for Scotland for the permission to publish this case.

## REVERSE SPONDYLOLISTHESIS

By E. H. HAMBLY

SURGEON, F.R.S. ROYAL NATIONAL ORTHOPEDIC HOSPITAL

REVERSE spondylolisthesis is a condition which is extremely rare. The accompanying radiographs show a spine with this congenital abnormality.

The patient is a girl, who was originally treated at the age of ten months with a back splint. At the age of 2 years she had great difficulty in walking, and at 2 years 6 months was treated in bilateral extension in a plaster bed. To-day, at 10 years of age, she has a complete bilateral spastic paraplegia. Four months ago she was walking with difficulty with an ugly gait.



FIG. 477.—Radiograph of spine at 2 years of age.

The first picture was taken in 1936, when the patient was two years of age; the second one shows the condition at the age of ten (*Figs. 477, 478*).

The third and fourth lumbar vertebrae have become fused, and lie posterior to the body of the fifth lumbar vertebra. Furthermore, the body of the second lumbar vertebra has sunk to lie upon the body of the fifth lumbar vertebra.



FIG. 478.—The spine at the age of 10 years.

She has since had both knees straightened and both Achilles tendons elongated.

She is now walking well. The question of exploration of the affected nerves has been considered, but as her present condition is relatively satisfactory, it has been decided to leave the spine alone.

I should like to thank Mr. V. H. Ellis for his kind permission to publish the case, and also Mr. E. Laming-Evans, C.B.E., for his help in regard to the present treatment.

# BASAL-CELL CARCINOMA OF FACE, WITH REMOTE METASTASES AND PATHOLOGICAL FRACTURES

BY ALEC SINGER

ORTHOPEDIC SURGEON, OLDCHURCH COUNTY HOSPITAL, ROMFORD

REMOTE metastases from a basal-cell carcinoma are extremely rare, and for them to cause pathological fractures is even rarer. The only other case I have been able to find in the literature is that described by Willis (1930). In the rare instances where metastases occur they are generally confined to the regional lymph-glands. Willis (1934), who reviewed the literature, accepted only three examples of remote metastases, and since then the only other case described has been that of De Navasquez (1941).

The present case is thought worthy of report because of the following features: (1) The unequivocal appearance of basal-cell carcinoma presented by the primary neoplasm. (2) The metastases in bone. (3) The pathological fractures of the femora. (4) The regional lymph-gland involvement. (5) The comparatively benign course of the primary neoplasm.

## CASE REPORT

The patient, Mary D., aged 72, was admitted to this hospital on March 30, 1944, following a fall at home. Apparently she attempted to climb the stairs on her way to bed and put her right foot on the lower stair in order to commence the ascent. The leg



FIG. 479.—Photograph of patient, showing basal-cell carcinoma eroding face. Note well-marked 'rolled' edge.

collapsed under her and she fell on to her left side. On examination, she was a frail old lady with obvious bilateral fractures of the upper thirds of the femora. There was a large, ulcerating neoplasm, with a 'rolled' edge, on the right side of her face, which extended on to the upper lip and had destroyed it in part. There was also a secondary ulcerating neoplasm in the right submaxillary region (Fig. 479).

VOL. XXXII—NO. 128

On further questioning, she stated that she had had an "ulcer" which had commenced just below the inner side of the right eye, and that it had never healed, but had gradually grown larger over a period of about five years, and that it had never troubled her very much!

X-ray examination showed pathological fractures of her femora (Fig. 480). I assumed that the fracture on the right was spontaneous, while that on the left



FIG. 480.—Radiograph showing pathological fractures of femora.

followed direct trauma to an already involved bone. There were also secondary deposits in her pelvis, but further radiographs of the upper and lower limbs, chest, and skull showed no evidence of metastases.

She died on April 4, following hypostatic pneumonia.

AT AUTOPSY.—This was performed by Dr. F. Camps on April 5. The external appearance showed her to be a thin, wasted, elderly woman, with an extensive ulcerated area involving the right cheek, upper lip, and nose, and extending down to the jaw. There was also a secondary ulcerating area in the right submaxillary region. In appearance these resembled rodent ulcers. There were also fractures involving both femora in the upper third, both of which on section showed areas clearly neoplastic in character, at the site of fracture. No involvement of meninges or brain.

Both lungs showed extensive consolidation of the lobar type. There was moderate hypertrophy of the left ventricle and atheroma of the aorta with some puckering. The valves were healthy. The pulmonary arteries were narrowed.

The liver showed chronic passive congestion and the kidneys fine, ischaemic changes. There was involvement of the right ilium with secondary deposits.

HISTOLOGICAL EXAMINATION (Dr. Gilmour).—

1. Two portions of skin showing basal-celled trabecular carcinoma and chronic inflammation in the dermis and subcutis, with ulceration of most of the surface (Fig. 481).

2. Portion of femur. Much similar secondary basal-cell carcinoma in spongiosa, porotic cortex, and periosteum (Figs. 482, 483).

3. Portion of ilium. Similar secondary carcinoma, some of it necrotic.



## DISCUSSION

It is now certain that transitional types between typical basal-cell carcinoma and squamous epithelioma exist, since both probably arise from



FIG. 481.—Section of skin showing basal-cell carcinoma with chronic inflammatory changes in dermis and subcutis, and ulceration of surface. ( $\times 50$ .)

the same germinal layer, though these transitional types show some degree of differentiation in either the primary neoplasm or its metastases. In the case reported here, the cells are quite

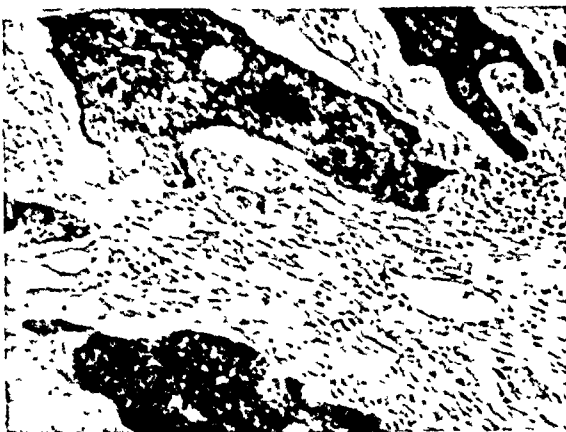


FIG. 482.—Section of femur showing invasion by basal-cell carcinoma. ( $\times 50$ .)

typical morphologically, and the metastases in the bone show no change in the degree of differentiation.

Spies (1930) states that after a careful search of the literature he has been unable to find any case in which definite, unmixed, basal-cell carcinomata arising from the skin gave rise to

widespread or distant metastases. However, Morton (1926) states that basal-cell carcinomata might give rise to regional metastases.

The mode of spread in this case is probably by two routes: (a) By the lymphatics to the submaxillary lymph-node, thus behaving like an epithelioma; (b) By the bloodstream, possibly as the result of direct erosion and infiltration of the angular vein. Albeit there was no macroscopical evidence of secondary deposits in the lungs, it is probable that there were minute malignant emboli present and that these cells had then passed directly into the systemic circulation, either by the method of spread as described by Schmidt or by direct passage through the pulmonary capillaries, and their further distribution as systemic arterial emboli.

In the case described by Willis (1930) he states that the neoplasm had a structure almost accurately intermediate between rodent ulcer and squamous epithelioma. This intermediate structure was adhered to throughout an "unusual metastatic life history." In this case the structure throughout is entirely that of a basal-cell carcinoma.

My thanks are due to Dr. E. Miles, Medical Superintendent, for permission to publish the case notes; and I am extremely indebted to Dr. C. B. Limerick for his able photography of both the patient and the histological sections.



FIG. 483.—High-power view of Fig. 482. Note typical malignant cells. ( $\times 500$ .)

## REFERENCES

- DE NAVASQUEZ, S. (1941), *J. Path. Bact.*, **53**, 437.  
 MORTON, J. J. (1926), *Arch. Surg., Chicago*, **12**, 655.  
 SPIES, J. W. (1930), *Ibid.*, **21**, 365.  
 WILLIS, R. A. (1934), *The Spread of Tumours in the Human Body*, 127. London.  
 — (1930), *J. Coll. Surg. Aust.*, **2**, 417.

## STRANGULATION OF THE OVARY AND FALLOPIAN TUBE IN AN OBTURATED HERNIA

BY D. P. VAN MEURS

ASSISTANT SURGEON, COUNTY HOSPITAL, FARNBOROUGH, KENT.

OBTURATOR hernia is an uncommon condition, and, when strangulation occurs, the diagnosis is not often made pre-operatively. In cases presenting as acute abdominal emergencies, this failure of diagnosis is not of great importance, so long as the condition is recognized at operation and the methods of releasing the strangulation, removing the sac, and repairing the orifice are familiar to the surgeon.

The importance of an accurate diagnosis is greater in those cases which have not resulted in strangulation, but which give signs of intermittent obstruction.

A case record is given in which the pre-operative diagnosis was not made, and yet on the history, symptoms, and physical signs there should have been little difficulty.

## CASE REPORT

**HISTORY.**—Mrs. D. B., aged 44, was brought into this hospital on Nov. 3, 1943, with a 15 hours' history of pain in the right iliac fossa, the right lumbar region, and down the inner side of the right thigh. She had nausea from the onset and had vomited once after taking a dose of bicarbonate of soda. Her bowels had not been open on the day of admission, but had previously been regular. There was no report of upset of micturition, but there had been some irregularity of her periods, presumably menopausal. The pain was moderately severe, steady in character, and most felt in the right iliac fossa. T. 99°, P. 72, R. 18.

She had had three previous similar, though milder, attacks, each lasting three days, and occurring 1 year, 8 months, and 4 months before admission.

She had rheumatic fever at the age of 14, a normal pregnancy 15 years ago, and for 15 years had occasional flatulence and epigastric pain occurring 1-3 hours after meals.

**ON EXAMINATION.**—Her general condition was good. Her tongue was slightly furred. There was no abdominal rigidity, but there was deep tenderness with some guarding low in the right iliac fossa. No mass could be felt; rectal examination showed no abnormality, but a vaginal examination revealed a small tender lump in the right fornix. The uterus was of normal size and mobility.

No other physical signs were elicited, and no diagnosis was made at this stage. The possibility of the case being one of obturator hernia was suggested, but, in view of the absence of signs of obstruction to the bowel, the idea was dropped.

The patient was watched, and the symptoms subsided somewhat over the next four days, except for the temperature, which rose irregularly to 100° F. The pulse showed a slight increase.

On Nov. 8 her symptoms became a little worse, and, still without making a definite diagnosis, I decided to operate.

**AT OPERATION.**—Through a lower midline incision, the mass felt per vaginam was found to be a partially

cystic right ovary, tightly jammed against the inner opening of the obturator canal. A loop of the right Fallopian tube was firmly fixed in the canal, with the fimbriated extremity just showing behind the ovary.

The ovary was first removed, and then the tube divided at the uterine end. The orifice was enlarged by spreading the blades of a hæmostat, and the tube withdrawn. Dark blood-stained fluid escaped. The tube was very elongated and gangrenous. The peritoneum forming the sac came out with the tube, the hernia being of a sliding type. The orifice admitted the little finger and was about 2 in. long, although the exact course that the hernia had taken could not be defined.

The peritoneum covering the obturator orifice was repaired, and the abdomen closed without drainage.

**PROGRESS.**—The patient made an excellent recovery, but had adductor weakness which gradually improved with physiotherapy until it could not be detected when the patient was last seen, 4½ months after admission. This had probably resulted from trauma to the nerve in freeing the hernia, but caused little inconvenience to the patient even when she first got up.

The patient was discharged on Nov. 29, but was subsequently readmitted for an attack of acute intestinal obstruction on March 2, 1944. At operation this was found to be due to a band strangulating a loop of small intestine, necessitating a resection of bowel. The patient again made a good recovery and was discharged on March 18.

## DISCUSSION

This patient had one symptom which is of importance—pain along the course of the obturator nerve. This symptom, described by Howship in 1840, and Romberg in 1845, is sometimes known as the Howship-Romberg sign, and according to Watson (1938), occurs in 50 per cent of all cases, whether strangulated or not. It probably occurs in a higher percentage of strangulated cases, being overclouded by the more predominant signs of acute obstruction. This, in conjunction with the tender mass in the region of the obturator canal, should have led to the diagnosis being made, although the absence of symptoms of intestinal obstruction was rather misleading.

Although obturator hernia is rare, when it does occur the usual absence of a palpable mass makes the diagnosis almost impossible unless the Howship-Romberg sign is borne in mind.

An exhaustive review of the literature has not been possible, but, according to Watson, hernia of the Fallopian tube into the obturator canal has been described in 7 cases. The rather anomalous symptoms make it worth while recording a further case.

## SUMMARY

1. A case is described of strangulated obturator hernia containing the Fallopian tube.
2. A pre-operative diagnosis could have been made on the available history, symptoms, and signs.
3. Stress has been laid on the value of the Howship-Romberg sign in the diagnosis of strangulated and non-strangulated obturator hernia.

Thanks are due to the County Medical Officer Dr. Ponder, and the Medical Superintendent, Dr. Hackwood, for permission to publish the case.

## REFERENCE

WATSON, LEIGH F. (1938), *Hernia*. London: Henry Kimpton.

## CONGENITAL ABSENCE OF CONTINUITY BETWEEN SMALL AND LARGE INTESTINE, WITH ABNORMAL BLOOD-SUPPLY OF THE PROXIMAL COLON

BY HERBERT HAXTON

FROM THE DEPARTMENT OF SURGERY, RADCLIFFE INFIRMARY, OXFORD

DEVELOPMENTAL anomalies of the intestines are not very rare, but no record has been found of a case similar to the one presented here.

## CASE REPORT

A male infant, 2 days old, had a history of repeated vomiting since birth, no feeds being retained. No meconium had been passed. The baby was full-time and well-nourished, with no external signs of

and the intestine was twisted round a peritoneal fold which enclosed the superior mesenteric artery. The twist was particularly tight just proximal to the terminal sac, which looked and felt to be infarcted, a finding later confirmed by histological section. The volvulus was undone, the sac excised, and the end of the small intestine brought through the abdominal wound, which was closed around it in layers with nylon sutures. The infant's condition deteriorated and despite resuscitative measures he died on the following day.

**AT AUTOPSY.**—The terminal inch of the small intestine was infarcted. The colon was complete in form, but diminutive and lying in the lower abdomen and pelvis, stuck to the posterior abdominal wall. The tiny cæcum had an appendix, and just above it was the terminal ileum represented by a small diverticulum of the colon. The blood-supply of the colon was derived from two arteries, both springing direct from the aorta, of which the upper supplied the right half of the colon. The venous drainage was by a normal inferior mesenteric vein to the splenic vein. (Fig. 484.)

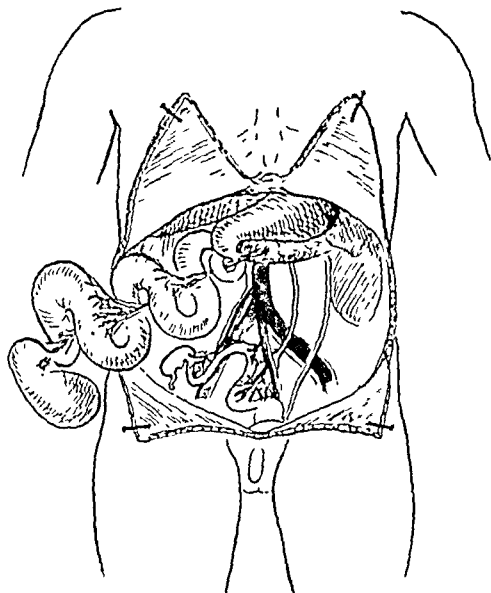


FIG. 484.—The blood-supply to the colon and small intestine.

abnormality except for a distended and tense abdomen. A finger passed into the rectum without difficulty, but the upper rectum felt narrow. Under the diagnosis of congenital intestinal obstruction the abdomen was opened under local infiltration anaesthesia.

The small intestine, grossly distended and congested, ended in a blind piriform sac. There was no mesenteric fixation to the posterior abdominal wall,

**DISCUSSION**

The normal pattern for the arterial supply of the intestines is that the mid-gut (duodenum to left side of transverse colon) is supplied by the superior mesenteric artery, and the hind-gut (transverse colon to rectum) by the inferior mesenteric artery. In this case, those branches which normally arise from the right side of the superior mesenteric artery, ileocolic, right colic, and mid-colic arteries, arose from a separate branch of the aorta, and the corresponding venous drainage accompanied that of the hind-gut. This abnormal blood-supply was possibly responsible for the breach of continuity in the intestinal tract, since it rendered the whole colon independent of the small intestine. The extensive fixation of the colon seemed to indicate that it had not shared in the mid-gut protrusion into the extra-embryonic coelom and the subsequent rotation which normally takes place in the 6th to 12th weeks of foetal life.

## A KNIFE-BLADE IN THE RETROPHARYNGEAL SPACE

By GERRIT M. MES

SURGEON, KRUGERSDORP HOSPITAL, TRANSVAAL, SOUTH AFRICA

I AM sure that the following case deserves the term 'rare', if ever there was one that did. The chances of this happening must have been several million to one.

## CASE REPORT

**HISTORY.**—A native male, Cucka, was admitted to hospital with a "sore throat" on Sept. 16, 1941. He was treated in the usual way with M & B and gargles. No particular attention was paid to him.

After a few days the slight fever dropped to normal temperature, but he kept on complaining of what seemed a disproportionate amount of pain. Inspection of the throat showed that the general swelling had subsided, but behind the left tonsil on the posterior wall of the pharynx there was a granulosomatous mass about the size of a sixpence. An otolaryngologist passing through the ward was shown the case, and he suspected a malignant growth. He advised radiography, to see whether the vertebræ were involved.

When the radiologist developed her plate, she thought that, inadvertently, some other body had cast a shadow on the plate, an impression that can easily be understood by referring to the accompanying reproduction (Fig. 485). A second plate, with another cassette, showed the same unbelievable shadow.

On more detailed investigation two points were elicited that explained the condition. Behind the left angle of the jaw, an inch-long, fine scar with stitch-marks was found, and, on being questioned about this, the patient said that he had been involved in a brawl about two years previously. He had received a wound, but the doctor had stitched him up, and there had been no further complaints.

On Sept. 30, under a general anæsthetic, and with the aid of a tonsillectomy gag, the retropharynx was inspected, and the foreign body clearly felt.

The granulosomatous mass was pushed aside, disclosing the broken end of the blade in its centre. This was grasped with a pair of forceps, and while an assistant stood ready to compress the carotid artery, in case the point had eroded the walls of that vessel, the blade was slowly pulled to the left and forward. It came out surprisingly easily.

There was no reaction, and the patient was discharged from hospital on Oct. 6.

The blade proved to be 3 in. long, the tip of what must have been a sheath-knife, thickly rusted and black.

**Discussion.**—The main interest in this case is in the things that did not happen. Anatomically, it would seem impossible, at first sight, to insert a knife behind the angle of the jaw, and into the retropharyngeal space, without injuring one or more of the sheaf of blood-vessels there. The only possibility

would be, that the knife was pushed in up to the vertebral column, and then slid along its anterior surface. A glance at the X-ray picture will, however, show that the point of the knife is now well past the level of the carotid vessels on the other side. The explanation for this can be that the head of the man turned (when the knife was in for slightly more than 3 in.), thus snapping off the tip of the blade; and that, in the



FIG. 485.—Antero-posterior and lateral radiographs showing the position of the knife-blade in the retropharyngeal space.

succeeding two years, the knife has travelled around the anterior surface of the vertebræ.

This would explain the fact that the knife-point is directed backwards. That the blade 'travelled' becomes still more probable when one considers that if the knife had broken off in the position it is now, there would have been only soft structures containing blood-vessels to withstand the lateral force on the tip of the blade; certainly not sufficiently strong to cause the nearly  $\frac{1}{2}$ -in. thick blade to break.

As a matter of fact the blade must have been snapped off by the head turning *towards* the knife, thus jamming the blade between the left angle of the jaw and the vertebral column.

As the knife started to point more and more backwards in its travels, the broken end of the blade, being pushed forward, must have eroded the posterior pharyngeal wall. This caused the granulosomatous mass, and the consequent infection which led to its discovery.

## SUMMARY

A case has been reported of 3 in. of the blade of a sheath-knife remaining in the retropharyngeal space for a period of at least two years, without causing much discomfort, and without its presence being suspected by the patient.

## REVIEWS AND NOTICES OF BOOKS

**X-Ray Examination of the Stomach.** A Description of the Roentgenology of the Esophagus, Physiology, and Pathology of the Stomach, and Duodenum. By FREDERIC E. TEMPLETON, M.D., Head of the Department of Roentgenology, The Cleveland Clinic. 9 x 6 in. Pp. 516 + iv, with 297 illustrations. 1944. Chicago: University of Chicago Press. (London: Cambridge University Press.) 60s. net.

THIS is a very practical and up-to-date book, and the author has written about his own material which has passed through his hands during the last sixteen years.

The filming fluoroscope has made possible a new method of examining the upper part of the alimentary canal. By using small amounts of barium the mucosal pattern is easily demonstrated, and any ridges, folds, nodules, or ulcers can be seen.

In some cases the "compression technique" is used, in which a greater amount of barium is given and compression of the abdominal wall maintained while the filming is in progress. Finally, the old method of "filled organ technique" is employed and the three results are compared and contrasted.

It must be acknowledged that advances in X-ray technique are due directly or indirectly to the development of new apparatus, and each year produces new gadgets which help in the radiographic equipment.

Doctor Templeton's book is more comprehensive than its title would lead the reader to suppose, for it is a description of the radiographic anatomy, physiology, and pathology of the œsophagus, stomach, and duodenum; in short, it covers the whole of the fore-gut of the human subject. Every type of abnormality is described and illustrated with excellent radiographs.

This book will prove of great value as a reference volume to surgeons, physicians, and radiologists.

**Notable Names in Medicine and Surgery.** By HAMILTON BAILEY, F.R.C.S. (Eng.), Surgeon, Royal Northern Hospital, London; and W. J. BISHOP, F.L.A., Sub-Librarian, Royal Society of Medicine. 7½ x 4½ in. Pp. 202 + viii, with 142 portraits and other illustrations. 1944. London: H. K. Lewis & Co., Ltd. 15s. net.

THE authors are to be congratulated on their industry in collecting these biographical notes with photographs of the 79 men and 2 women whose names are used as they say on their preface "in the wards, and in the operating theatres, in the out-patient department and in the lecture theatre, in general practice and indeed in the everyday contact between medical and allied professions". It is somewhat invidious that some of the biographical sketches should have been prepared first of all for nurses in *Nursing Illustrated* rather than for medical students. The present volume remedies the omission, and it is to be hoped that the latter will now take advantage of the opportunity to learn something of the man whose name is attached to an expression in daily use such as "Lugol's solution, Fowler's position, Colles's fracture, Wassermann's reaction, etc."

The subject of medical history is still the Cinderella of the Medical Curriculum, and even though the

latter is by general agreement overloaded with breaking news, it is not to be done about it. The Report does not mention imaginative and creative literature, poetry, drama, and novels, contains more medical history than any text-book on medicine. For instance, to learn what war wounds were like at Blenheim one must go to the pages of Thackeray's *Esmond*.

Medical history should be discipline for the mind and inculcate into the student a habit whereby in later life he is able to implement the advice of St. Paul to the Thessalonians, "Prove all things, hold fast to that which is good".

In Fielding H. Garrison's classical *An Introduction to the History of Medicine*, he states that the approach to medical history should be four-fold: graphic, biographic, historical, and cultural. The authors in a modest way follow this precept. If it does nothing more than stimulate the student to possess Garrison's book, it will not have been written and published in vain.

The book only deals with eponyms, so many well-known names are omitted, e.g., William Harvey, Lord Lister, and Louis Pasteur, to mention only three whose work did more for modern medicine than all the others, but if it achieves its purpose, then it should stimulate the student to make himself acquainted with their biography.

It seems a pity that well-known names in science, art, and industry are not perpetuated more in our everyday life, though the municipalities do not overlook them altogether in the naming of streets. In other countries, their portraits are perpetuated on postage stamps, but the loyal British have never succumbed to such temptation—perhaps our educationalists will ponder the matter in these days of 'planning'.

Only two women are included—Mesdames Dejerine-Klumpke and Marie Curie. Many will remember the sparse notice that the Press took of the latter's death on July 4, 1934, a martyr to her work. The headlines at the time were filled with the England v. Australia cricket match results, double centuries were being made, and the whole country waited breathlessly for the luncheon score.

But whatever the inclination of the student may be, the short biographical notes in this book should convince him that

Fame is the spur that the clear spirit doth raise  
(That last infirmity of noble mind)  
To scorn delights and live laborious days.

**The Urinary Tract.** A Handbook of Roentgen Diagnosis. By H. DABNEY KERR, M.D., Professor of Radiology, State University of Iowa College of Medicine, and CARL L. GILLIES, M.D., Associate Professor of Radiology, State University of Iowa College of Medicine. 8 x 5½ in. Pp. 320, with numerous illustrations. 1944. Chicago: The Year Book Publishers Inc. (London: H. K. Lewis & Co. Ltd.) 34s. net.

THIS book is essentially a radiographic atlas of the urinary tract; it is at the same time much more than an atlas by virtue of the accounts which introduce each section, and of the admirable descriptions

accompanying the plates. Although the authors are radiologists, they recognize the limitations of their speciality and do not base their diagnoses solely on X-ray findings, but also on correlated clinical and pathological evidence. This is refreshing at a time when too many conclusions are being made on radiographs alone. The clinician should make full use of radiology, for whilst cystoscopy will usually give an accurate idea of the nature of a bladder tumour, cystography will often add valuable information about its extent, and will provide a permanent record.

The authors have drawn on a wide experience, and there is scarcely a lesion of the urinary tract not included; several examples of each condition are shown to indicate the variations in every abnormality. The quality of the pictures is excellent despite their reduced size, and the arrangement is such that the caption is placed conveniently opposite its illustration. This is a volume which will become an indispensable reference book to all urologists and radiologists.

**Operations of General Surgery.** By THOMAS G. ORR, M.D., Professor of Surgery, University of Kansas School of Medicine, Kansas City, Kansas.  $10\frac{1}{2} \times 7\frac{1}{2}$  in. Pp. 723 + viii, with 1396 illustrations on 570 figures. 1944. Philadelphia and London: W. B. Saunders Co. Ltd. 60s. net.

THIS is a new book and contains a large number of original illustrations. The author has had an extensive experience in the teaching and practice of surgery and has chosen his material well, and his drawings and pictures illustrate the text in an excellent manner. Every book on operative surgery is enhanced by good illustrations, and this book is no exception to the rule.

All modern operative procedures are discussed and described, including operations on the sympathetic nervous system, the endocrine system, and the genito-urinary system. While not agreeing with the author on the operations described for partial nephrectomy and plastic operations on cases of hydronephrosis, one is pleased to see that a scrotal approach is used for operations on the testicle. The inguinal approach, which is not direct, had held the field too long and should be abolished.

The operations on the female reproductive system are practical and up to date. Every general surgeon may be called upon to do any of these operations, and they should always find a place in any text-book on operative technique.

The book will take its place in the library of every surgeon who is keen on the teaching of operative surgery to the younger generation.

**Textbook of Anaesthetics.** By R. J. MINNITT, M.D. (Liverp.), D.A., Lecturer in Anaesthesia, University of Liverpool; etc.; and JOHN GILLIES, M.C., M.B., Ch.B. (Edin.), D.A., Consultant in Anaesthetics, Department of Health for Scotland; Anaesthetist, Professorial Surgical Unit, Royal Infirmary, Edinburgh; etc. Sixth edition.  $8\frac{1}{2} \times 5\frac{1}{2}$  in. Pp. 487 + viii, with 199 illustrations. 1944. Edinburgh: E. & S. Livingstone, Ltd. 25s. net.

ISSUED as a *Handbook of Anaesthetics* in 1919, this manual has reached its sixth edition, and from its metamorphosis has emerged as a more or less complete *Textbook of Anaesthetics*. We say 'more or

less' because in their endeavour to cover more comprehensively a rapidly growing subject the authors have included a chapter on Local and Regional Analgesia. This chapter is excellent, and is written by Major L. B. Wevill, who is to be congratulated on his success in compressing so much information into such limited space. This is, however, a text-book and not a synopsis, and we trust that in a subsequent edition the authors will reserve triple the space here afforded, or even produce a second volume, so as to bring the text of this section up to the level of complete and comprehensive cover so admirably attained in the rest of this valuable book.

New chapters have, with advantage, been included on trichlorethylene, endotracheal anaesthesia, intravenous anaesthesia, and anaesthesia for dentistry.

The book is well arranged, and the text is easy to read and to understand. The illustrations are numerous and clearly produced, and both the authors and the publishers are to be congratulated on the production of this manual, which, in our opinion, is the best modern text-book of anaesthetics extant.

**The American Academy of Orthopaedic Surgeons Presents Lectures on Reconstruction Surgery.** Selected from the Instructional Courses of the Twelfth Annual Assembly, Chicago, January 23-24, 1944. Edited by JAMES E. M. THOMSON, M.D., Lincoln, Nebraska, Chairman of the Instructional Section.  $10\frac{7}{8} \times 8\frac{1}{2}$  in. Pp. 568 + iv, with many illustrations. 1944. Ann Arbor, Mich.: Edwards Bros. Inc. (London: H. K. Lewis & Co. Ltd.) £2 9s. net.

THESE lectures were selected from the instructional courses of the twelfth annual assembly of the American Academy of Orthopaedic Surgeons held in Chicago in January, 1944.

Every form of deformity of the skeleton is included in this large volume, and every form of modern orthopaedic operation is described and illustrated with radiographs, drawings, and photographs.

The treatment of non-union of fractures is very well described by a number of authors. Bone-grafting and the use of tantalum wire and nails are given full prominence.

It is interesting to observe that orthopaedic surgery in America has taken plastic surgery and the surgery of burns under its wing.

This volume is in reality a series of lectures given by various orthopaedic surgeons and of necessity some are better than others. As a reference book it will prove a useful addition to the orthopaedic library of any surgeon interested in this subject.

**Studies of Burns and Scalds** (Reports of the Burns Unit, Royal Infirmary, Glasgow, 1942-43). *Medical Research Council, Special Report Series* No. 249.  $9\frac{1}{2} \times 6$  in. Pp. 210, with 50 illustrations. 1945. London: H.M. Stationery Office. 4s. net.

THIS publication is No. 249 of the Special Report Series of the Medical Research Council. Here are recorded the conclusions of a team of surgeons and laboratory workers who had special facilities for a systematic study of some 400 in-patients with burns and nearly 2000 out-patients with less severe burns. Dr. Leonard Colebrook directed the laboratory studies and co-ordinated them with the clinical findings.

The monograph deals mainly with two important aspects of the burns problem, namely, the control of infection and the treatment of shock. Part I treats of first aid to burns, the importance of asepsis from the first, and the recommendation of an antiseptic cream. Part II contains very important observations on the dangers of infection and recommendations for its prevention and control by chemotherapy. Parts III and IV deal with the important and difficult problem of shock and replacement therapy. Part V

gives a summary of the biochemical changes in a series of 70 burned patients, and Part VI gives the post-mortem findings in 30 fatal cases.

Here is a substantial contribution made by first-class workers towards the solution of the 'burns problem'. The importance of the problem is well known to all surgeons and workers in industry. Its relative importance in war is shown by the statement in the Preface that "At El Alamein, one in four of the battle casualties were of this nature".

## BOOK NOTICES

*[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.]*

**Shoulder Lesions.** By H. F. MOSLEY, M.A., D.M., M.Ch. (Oxon.), F.R.C.S., (Eng. and C.), F.A.C.S., Lecturer in Surgery, McGill University; Assistant Surgeon, Royal Victoria Hospital, Montreal. 9½ × 6½ in. Pp. 181 + xi, with 70 illustrations. 1945. Springfield, Ill.: Charles C. Thomas. (London: Baillière, Tindall & Cox.) \$4.50.

**Bone-grafting in the Treatment of Fractures.** By J. R. ARMSTRONG, M.D., M.Ch., F.R.C.S., A/W/Comm. R.A.F.M.S., and Surgeon-in-Charge of an R.A.F. Orthopaedic and Fracture Centre; Registrar to the Orthopaedic Department and to the Fracture Clinic, Charing Cross Hospital, London; Registrar to the Metropolitan Hospital, London. With a Foreword by R. WATSON-JONES, B.Sc., M.Ch.Orth., F.R.C.S., Civilian Consultant in Orthopaedic Surgery of the R.A.F. 9½ × 6½ in. Pp. 175 + xii, with 204 illustrations. 1944. Edinburgh: E. & S. Livingstone Ltd. 25s. net.

**Urological Surgery.** By AUSTIN INGRAM DODSON, M.D., F.A.C.S., Professor of Urology, Medical College of Virginia; etc. With contributions by seven authors. 9½ × 6½ in. Pp. 768, with 576 illustrations. 1945. London: Henry Kimpton. 50s. net.

**Surgery. A Textbook for Students.** By CHARLES AUBREY PANNETT, B.Sc., M.D., F.R.C.S., Professor of Surgery, University of London; Director of the Surgical Unit, St. Mary's Hospital, London. 9½ × 6½ in. Pp. 740 + xii, with numerous illustrations. 1944. London: Hodder & Stoughton Ltd. 35s. net.

**The 1944 Year Book of Industrial and Orthopaedic Surgery.** Edited by CHARLES F. PAINTER, M.D., Orthopaedic Surgeon to the Massachusetts Women's Hospital and Bath Israel Hospital, Boston. 7 × 4½ in. Pp. 432, with 282 illustrations. 1945. Chicago: The Year Book Publishers Inc. (London: H. K. Lewis & Co. Ltd.) 18s. net.

<b>ABDOMINAL</b> distension due to adrenal neuroblastoma - - - - -	79, 82	<b>BARNARD, W. G. :</b> <i>See</i> <b>BARRETT, N. R.,</b> jt. auth.	
— injuries associated with wounds of colon - - - - -	340	<b>BARRETT, N. R. :</b> Right retroperitoneal diaphragmatic hernia - - - - -	421
— surgery of 'total war', second thoughts on - - - - -	247	— — and <b>BARNARD, W. G. :</b> Some unusual thoracic tumours - - - - -	447
— wall, musculature of - - - - -	441 et seq.	<b>Basingstoke, Canadian Neurosurgical Centre,</b> Hackwood Park, visit to - - - - -	525
<b>Abdomino-thoracic</b> penetrating wounds - - - - -	255	<b>Basophil</b> adenoma of pituitary (Cushing's syndrome) - - - - -	97
<b>ABRAHAM J. JOHNSTON :</b> The early history of syphilis - - - - -	226	<b>Battle</b> casualties ( <i>see</i> War) - - - - -	
<b>Abscess</b> of brain, penicillin in - - - - -	205	<b>BEACH, W. V. :</b> Inguinal hernia - - - - -	499
— colon, intramural, case report - - - - -	325	<b>BELCHER, J. R. :</b> A case of rupture of a congenital discoid cartilage - - - - -	435
— pelvic, intraperitoneal chemotherapy in - - - - -	58	<b>Bell, Benjamin,</b> on venereal diseases - - - - -	232
<b>Acromio-clavicular</b> dislocation, operative repair of, case report - - - - -	103	<b>BENTLEY, F. H. :</b> The treatment of flesh wounds by early secondary suture and penicillin - - - - -	132
<b>Actinomycosis</b> from punch injuries - - - - -	506	<b>BICKERTON, J. G. :</b> <i>See</i> <b>McEWAN, R. J. B.,</b> jt. auth. - - - - -	
<b>Adenoma, basophil, of</b> pituitary (Cushing's syndrome) - - - - -	97	<b>Bile-duct,</b> common, cyst containing stones and undergoing cancerous change - - - - -	319
— of bronchus - - - - -	449	<b>Bile-ducts,</b> wounds of - - - - -	254
— kidney, malignant transformation in - - - - -	315	<b>BINGHAM, J. A. W., and McDONALD, STUART, jun. :</b> A filarial nodule simulating a cyst of the external semilunar cartilage, case report - - - - -	326
<b>Adhesions,</b> intraperitoneal chemotherapy and - - - - -	55, 56	<b>BIRKETT, A. N. :</b> The result of operative repair of severe acromio-clavicular dislocation, case report - - - - -	103
<b>Adrenal</b> cortical extract in shock - - - - -	73	<b>Bladder, calculus of,</b> large, passed per (female) urethram, case report - - - - -	323
— gland in shock - - - - -	70	— injuries of - - - - -	44
— neuroblastoma - - - - -	78	— wounds of - - - - -	254
— virilism - - - - -	90	<b>Blood, assay of</b> penicillin in - - - - -	123
<b>Aerial warfare, penicillin</b> prophylactically in wounds of - - - - -	207	— concentrations of sulphonamides after intraperitoneal implantation - - - - -	51, 52
<b>Agar cup</b> method of determining sensitivity to penicillin - - - - -	117	— examination in plasmocytoma - - - - -	474
<b>Age</b> incidence of appendicitis - - - - -	366	— transfusion in abdominal surgery - - - - -	256
— — malignant tumours of small intestine - - - - -	479	— — gas gangrene in Italy - - - - -	159
<b>Agranulocytosis</b> due to intraperitoneal chemotherapy - - - - -	55	— — shock - - - - -	72
<b>Air</b> contamination in hospital ward, wound infection and - - - - -	428	<b>Blood-plasma</b> basket for dropping by parachute - - - - -	280
— embolism, a curious case of - - - - -	433	— transfusion in shock - - - - -	72, 73
<b>Airborne</b> division, surgery in - - - - -	275	— in war surgery in R.A.F. - - - - -	18
<b>Albee</b> bone-grafting in pseudo-arthritis of metacarpals - - - - -	465	<b>Blood-pressure</b> in shock - - - - -	69
<b>Albumin</b> in treatment of shock - - - - -	73	<b>Blueness</b> of skin after intraperitoneal chemotherapy - - - - -	54
<b>Amputations</b> in open fractures of femur, penicillin and - - - - -	149	<b>Body fluids, assay of</b> penicillin in - - - - -	122
— war surgery in R.A.F. - - - - -	19	— — effect of penicillin on - - - - -	113
<b>Anæsthesia</b> in maxillo-facial surgery in Middle East - - - - -	237	<b>Bone, plasmocytoma</b> of - - - - -	471
<b>Aneurysm, intracranial, carotid</b> ligation for - - - - -	309	— plasticity of - - - - -	345
<b>Antiserum</b> in gas gangrene in Italy - - - - -	160	<b>Bone-grafting</b> in conservation of metacarpus - - - - -	464
<b>Appendicitis, acute, and the appendix</b> mass - - - - -	365	<b>Bone-plating</b> in battle casualty fractures in Italy - - - - -	146
— intraperitoneal chemotherapy in - - - - -	57	— open fractures of femur - - - - -	151
— obstructive - - - - -	468	<b>Botterell, Lt.-Col. E. H., at the Canadian Neurosurgical Centre, Basingstoke</b> - - - - -	525
<b>Appendix</b> mass, acute appendicitis and - - - - -	365	<b>BOWEN, W. H. :</b> Obstructive appendicitis - - - - -	468
<b>Arm, wounds</b> of, in Middle East - - - - -	243	<b>BRAILSFORD, J. F. :</b> Plasticity of bone - - - - -	345
<b>Army</b> progress with penicillin - - - - -	110	<b>Brain</b> abscess, penicillin in - - - - -	205
<b>Arterial</b> ligation or spasm in aetiology of traumatic ischaemia of peripheral nerves - - - - -	409	<b>Breast</b> cancer in case of adrenal virilism - - - - -	95, 96
<b>Arteriography</b> in study of Volkmann's contracture - - - - -	259, 272	<b>Bromfield, William,</b> founder of London Lock Hospital - - - - -	235
<b>Arteriovenous</b> communication, unusual type of, case report - - - - -	321	<b>Bronchogenic</b> cyst, congenital deficiency of pericardium with - - - - -	357
<b>Astrology</b> and the origin of syphilis - - - - -	226	<b>Bronchus, adenoma</b> of - - - - -	449
<b>Azruc, Jean,</b> on syphilis - - - - -	232	<b>Broth</b> dilution method in assay of penicillin - - - - -	119
<b>Auzias-Turenne,</b> syphilization of - - - - -	234	<b>BROWN, JAMES J. MASON :</b> Early closure of soft tissue wounds with chemotherapeutic agents - - - - -	140
<b>BACK, burns</b> of, in Middle East - - - - -	244	<b>BUCKLEY, WILLIAM :</b> Malignant transformation in a previously benign tubular adenoma of the kidney - - - - -	315
— Bacteria sensitive and resistant to penicillin - - - - -	113	<b>Bunyan-Stannard</b> ( <i>see also</i> Stannard) - - - - -	
<b>Bacterial</b> endocarditis, subacute, complicating patent ductus arteriosus - - - - -	2	— envelope treatment of burns and wounds with skin loss - - - - -	24
<b>Bacteriological</b> examination of wounds treated with penicillin - - - - -	129	<b>Burn</b> Centres in R.A.F. hospitals - - - - -	
— methods in connexion with penicillin treatment - - - - -	117		
<b>Bacteriology</b> of flesh wounds - - - - -	135		
— gas gangrene in Italy - - - - -	165		
— open fractures of femur - - - - -	147		
— 'secondary' peritonitis - - - - -	50		
— wounds of aerial warfare - - - - -	209		



- Burns, chronic, H.E.P. in healing of - - - 521  
 — depth of skin destruction in - - - 32  
 — in Middle East, plastic repair of - - - 244  
 — Royal Air Force - - - 12  
 — and wounds with skin loss, treatment by envelope method - - - 24  
 BURROWS, H. JACKSON: Actinomycosis from punch injuries - - - 506  
 Bursitis, retrocalcaneal - - - 494
- CADE, STANFORD: War surgery in the Royal Air Force - - - 12  
 CAIRNS, HUGH: Penicillin in head and spinal wounds - - - 199  
 Calcaneus, abnormality of, as a cause of painful heel - - - 494  
 Calculus(i) in congenital cyst of common duct with cancerous change - - - 319  
 — ureteric, of unusual size - - - 524  
 — vesical, large, passed per (female) urethram, case report - - - 323  
 Canadian Neurosurgical Centre, Hackwood Park, Basingstoke, visit to - - - 525  
 Cancerous change in benign adenoma of kidney - - - 315  
 — — congenital cyst of common duct with stones - - - 319  
 Canine fossa approach for fractures of zygomatic tripod - - - 297  
 Capillary injury and pathology of shock - - - 70  
 Carcinoma of breast in case of adrenal virilism 95, 96  
 — face, basal-celled, with remote metastases and pathological fractures, case report - - - 537  
 — kidney, bilateral - - - 399  
 — mouth and jaws, recent advances in treatment - - - 35  
 — œsophagus, presterlinal œsophago-gastrostomy and removal - - - 394  
 — — resection and œsophago-gastrostomy - - - 377  
 — prostate in a youth, case report - - - 533  
 — and sarcoma of lung, mixed - - - 454  
 — scar, of the lung and the upper sulcus tumour of Pancoast - - - 85  
 — of small intestine - - - 481  
 Carotid artery, internal, traumatic thrombosis of, case report - - - 105  
 — ligation for intracranial aneurysm - - - 309  
 de las Casas, Bartholome, on origin of syphilis - - - 229  
 Catheterization in bladder injuries - - - 46  
 Cerebrospinal fistula, penicillin in - - - 205  
 Cheek, carcinoma of - - - 37  
 — wounds in Middle East, plastic surgery in - - - 241  
 Chemotherapy (see also Penicillin; Sulphonamides)  
 — in early closure of soft tissue wounds - - - 140  
 — intraperitoneal - - - 49  
 — in war surgery in R.A.F. - - - 18  
 Chest, foreign bodies in, penicillin in surgical removal of - - - 179, 190  
 — penetrating wounds of, intrapleural penicillin in - - - 176  
 — penicillin in treatment of war wounds of - - - 179  
 — unusual tumours of - - - 447  
 Chin, wounds of, in Middle East, plastic repair of 'China root' in syphilis - - - 231  
 Chloroform anaesthesia in buccal carcinoma - - - 38  
 Cholesteatoma of the petrous bone - - - 75  
 Church, the, on syphilis in A.D. 1495 - - - 226  
 Cicatrization of isolated inflammatory lesions of small intestine, stricture from - - - 371  
 CLARK, JOHN M. P.: See FURLONG, RONALD, jt. auth.  
 Clavicle, osteomyelitis of - - - 466  
 — and scapula, fascial sling for, in dropped shoulder and winged scapula - - - 311  
 CLAYTON-COOPER, BARBARA: See WILLIAMS, ROBERT, E. O., jt. auth.
- Clostridium causing gas gangrene - - - 165, 168  
 Colles's law - - - 233  
 Colon, absence of continuity with ileum, case report - - - 540  
 — intramural abscess of, case report - - - 325  
 — surgery of, intraperitoneal chemotherapy in - - - 59  
 — wounds of - - - 337  
 — — exteriorization in - - - 253  
 Colostomy in wounds of colon, closure of - - - 344  
 Columbus and the appearance of syphilis in Europe - - - 228  
 Concretion formation in diverticulosis - - - 462  
 Cone, Lt.-Col. W. V., at the Canadian Neurosurgical Centre, Basingstoke - - - 525  
 Congenital absence of continuity between ileum and colon, case report - - - 540  
 — cyst of common duct containing stones and undergoing cancerous change - - - 319  
 — deficiency of the pericardium associated with a bronchogenic cyst - - - 357  
 — discoid cartilage, rupture of, case report - - - 435  
 Conservative treatment in appendix mass cases - - - 365  
 Contracture, Volkmann's ischaemic - - - 409  
 — — nerve lesions in - - - 259  
 Contusions of bladder - - - 44  
 Cooling in treatment of frost-bite in R.A.F. - - - 21  
 Cooper, Astley, on acquired diverticulosis of jejunum - - - 457  
 Creams, penicillin - - - 115  
 — assay of - - - 122  
 Crohn's disease in a child - - - 512  
 — stenosis due to - - - 371, 375  
 Crymble, P. T.: Ulcer of the second part of the duodenum - - - 500  
 Cuboid, dislocation of, case report - - - 534  
 CURR, J. F.: Complete rupture of the pancreas - - - 386  
 Cushing's syndrome - - - 97  
 Cutis graft repair of hernia - - - 382  
 CUTLER, ELLIOTT C., MORTON, PAUL C., and SANDUSKY, WILLIAM R.: Observations on the prophylactic use of penicillin in the wounds of aerial warfare - - - 207  
 — — and SANDUSKY, WILLIAM R.: Treatment of clostridial infections with penicillin - - - 168  
 Cuvier, ducts of, embryology - - - 361  
 Cylinder method of determining sensitivity to penicillin - - - 118  
 Cylinder-plate method in assay of penicillin - - - 120  
 Cyst(s), bronchogenic, congenital deficiency of pericardium with - - - 357  
 — of common duct, congenital, containing stones and undergoing cancerous change - - - 319  
 — dermoid, of ovary in case of adrenal virilism 92, 96  
 — of external semilunar cartilage, filarial nodule simulating, case report - - - 326  
 — foreign-body, of triceps muscle, case report - - - 327  
 — prepericardial - - - 447  
 Cystoscopy in bladder injuries - - - 47
- D'ABREU, A. L., LITCHFIELD, J. W., and THOMSON, SCOTT: Penicillin in the treatment of war wounds of the chest - - - 179  
 Decompensated shock - - - 66, 67  
 Degloved hand, conservative operation in - - - 464  
 Dental riffler in operation for retrocalcaneal bursitis - - - 497  
 Dermatitis during envelope treatment of burns, etc. - - - 26  
 Dermoid cysts, ovarian, in case of adrenal virilism 92, 96  
 Diaphragmatic hernia in abdomino-thoracic injury 344  
 — — right retroperitoneal - - - 421  
 — — traumatic - - - 391  
 Diet in duodenal feeding in gastric ulcer 307, 308  
 Diplopia in fractures of zygomatic tripod 296, 299

# INDEX

Discoid cartilage, congenital, rupture of, case report -	435	<b>F</b> ACE, basal-cell carcinoma of, with remote metastases and pathological fractures, case report -	547
Dislocation, acromio-clavicular, operative repair of, case report -	103	— wounds, plastic surgery in, in Middle East -	537
— of cuboid, case report -	534	Facial deformity in fractures of zygomatic tripod -	238
— hip-joint, plasticity following -	355	— paralysis due to cholesteatoma of petrous bone -	296
Diverticulitis from acquired diverticulosis -	458	Faecal stagnation, obstructive appendicitis and -	75
Diverticulosis of jejunum and ileum, acquired, complications of -	58	Fallopian tube and ovary, strangulation of, in obturated hernia, case report -	468
Diverticulum, duodenal, secondary to gastric ulcer, case report -	457	Fascia in hernia repair -	539
— Meckel's, inverted, acute intussusception due to, case report -	434	— lata in repair of severe acromio-clavicular dislocation -	381
— — volvulus of ileum due to -	328	Fascial slinging of scapula and clavicle for dropped shoulder and winged scapula -	104
DORLING, G. C.: Fascial slinging of the scapula and clavicle for dropped shoulder and winged scapula -	510	Feeding, duodenal, in gastric ulcer, gastroscopic control of -	311
Drainage in open fractures of femur -	311	Femur, fractures of, in battle casualties, penicillin in treatment -	303
Dressings for burns in Middle East -	152	— — in war in Italy, penicillin in treatment -	154
Dropped shoulder, fascial sling for -	244	— neck, fracture of, plasticity due to -	144
Ducts of Cuvier, embryology -	311	— open fractures of, penicillin to control infection in -	354
Ductus arteriosus, anatomy and physiology of -	361	— pathological fractures of, with basal-cell carcinoma of face, case report -	147
DUGGAN, N.: An unusually large lipoma, case report -	1	Fibrosis of bone, plasticity in -	537
DUNPHY, J. E.: Shock: a consideration of its nature and treatment -	324	Filarial nodule simulating cyst of external semilunar cartilage, case report -	350
Duodenal diverticulum secondary to gastric ulcer, case report -	66	First aid for R.A.F. air-crews -	326
— feeding in gastric ulcer, gastroscopic control of -	434	Fistula, cerebrospinal, penicillin in -	22
Duodeno-jejunoscopy for stricture in Crohn's disease -	303	Fistula, repair of, in Middle East -	205
Duodenum, ulcer of second part of -	375	Flesh wounds, early secondary suture and penicillin in -	245
Dust contamination in hospital ward, wound infection and -	500	FLOREY, H. W., and JENNINGS, M. A.: The principles of penicillin treatment -	132
<b>E</b> AR wounds in Middle East, plastic repair of -	428	Fluorescein in determination of degree of burn -	112
EBRILL, DENIS: A case of regional enteritis in childhood -	242	Foreign bodies in chest, penicillin in surgical removal of -	13
Ectopic adrenocortical tissue in adrenal virilism -	512	— — retained intraventricular -	179, 190
Editorial:—	95	Foreign-body cyst of triceps muscle, case report -	414
Electro-encephalography in intracranial aneurysm -	109	Fournier, Alfred, on treatment of syphilis -	327
Electromyography in study of Volkmann's contracture -	309	FOWLER, A., and PHILIP, J. F.: Abnormality of the calcaneus as a cause of painful heel -	236
ELLIS, MAXWELL: A case of reversed rotation of the mid-gut and intestinal obstruction -	259, 272	Fracastor on syphilis -	494
Embolism, air, a curious case of -	101	Fracture(s) in battle casualties in Italy, penicillin in treatment -	144
Emphysema, surgical, of face due to fractures of zygomatic tripod -	433	— of femur in R.A.F. hospitals -	23
Endarteritis, subacute bacterial, complicating patent ductus arteriosus -	296	— — department in R.A.F. hospitals -	154
Enteritis, regional, in childhood -	2	— — of femur in battle casualties, penicillin in treatment -	354
Envelope treatment of burns and wounds with skin loss -	512	— — neck, plasticity due to -	147
Epiglottitis, cancer of -	24	— — open, penicillin to control infection in -	503
Epistaxis, unilateral, in fractures of zygomatic tripod -	40, 41	— — lumbar transverse processes, pseudarthrosis following -	242
Epithelioma of ovary in case of adrenal virilism -	296	— — malar, in Middle East -	537
Ether per rectum for anaesthesia in buccal carcinoma -	92, 93, 96	— — pathological, with basal-cell carcinoma of face, case report -	514
EVANS, P. R., and MURLEY, R. S.: A curious case of air embolism -	39	— of vertebrae, delayed paraplegia following -	287
Ewing's sarcoma, diagnosis from adrenal neuroblastoma -	433	Fracture-dislocation of occipital bone -	522
Exanthemata, scoliosis due to -	82	FRASER, KENNETH: Malignant tumours of the small intestine -	479
<b>Experimental Surgery:</b> —	346	FREEMAN, HARRY: A gastroscopic control of the treatment of gastric ulcer by duodenal feeding -	303
Extraperitoneal injuries of bladder -	425	Frost-bite in war surgery in R.A.F. -	19
Extraperitonealization in wounds of colon -	45 et seq.	FURLONG, RONALD, and CLARK, JOHN M. P.: On the use of penicillin to control infection in open fractures of the femur -	147
Eyelids, burns of, in Middle East -	343	Furunculosis during envelope treatment of burns, etc. -	26
— plastic surgery for wounds of, in Middle East -	240	<b>G</b> ALL-BLADDER, wounds of -	254
		— Gangrene, gas, in Italy, penicillin in treatment -	159
		— — penicillin in -	168
		— of hand, conservation of metacarpus in -	465

- GARDINER, R. H. : Intraperitoneal chemotherapy 49  
 GARDNER, A. D. : See ORR-EWING, JEAN, jt. auth.  
 GARROD, L. P., and HEATLEY, N. G. : Bacteriological methods in connexion with penicillin treatment - 117  
 Gas gangrene in Italy, penicillin in treatment - 159  
 — penicillin in - 168  
 — œdema - 166  
 Gastrectomy, aseptic anastomosis in - 418  
 Gastric ulcer, duodenal diverticulum secondary to, case report - 434  
 — — gastroscopic control of duodenal feeding in - 303  
 Gastroscopic control in duodenal feeding in gastric ulcer - 303  
 Generalized bone diseases, plasticity due to - 347  
 Genitalia, wounds of, in Middle East - 243  
 GILLIES, Sir HAROLD : Operative replacement of the mammary prominence - 477  
 — JAMES C. : Acute intussusception due to inverted Meckel's diverticulum, case report 328  
 Glove, Stannard, in burns in R.A.F. - 13  
 Gonorrhœa, confusion with syphilis in early days — penicillin therapy in - 231  
 GORDON-TAYLOR, GORDON : Second thoughts on the abdominal surgery of 'total war' — a review of over 1300 cases - 247  
 GRAY, TINA : Osteomyelitis of the clavicle - 466  
 GROVES, Ernest William Hey, in memoriam - 432  
 Growth-promoting substance in indolent wounds, value of - 281  
 — — wound treatment, further observations on value of - 518  
 Grünpeck, Joseph, secretary to Emperor Maximilian, on syphilis - 226  
 Guaiacum in syphilis, history of - 230  
 Gutter plate method of determining sensitivity to penicillin - 117
- HÆMATOCRIT** changes in shock - 68  
 Hæmatogenic shock - 66, 67  
 Hæmoconcentration - 68  
 Hæmolytic streptococcus in chronic septic war wounds - 129  
 Hæmorrhage from diverticulosis - 463  
 — into maxillary antrum in fractures of zygomatic tripod - 296  
 — secondary, in abdominal wounds - 258  
 — — wounds in Middle East - 245  
 — and shock - 68  
 Hæmothorax, penicillin in - 176
- HAMBLY, E. H. : Reverse spondylolisthesis, case report - 536  
 Hand(s), actinomycosis of, due to punch injury 506  
 — burns of, in R.A.F. - 13  
 — injuries, conservation of metacarpus in - 464  
 — — severe, a conservative operation for, case report - 535  
 — wounds of, in Middle East - 243
- HANLEY, HOWARD G. : Bilateral renal carcinoma 399  
 HAXTON, HERBERT : Congenital absence of continuity between small and large intestine, with abnormal blood-supply of the proximal colon, case report - 540
- Head injuries in R.A.F. - 21  
 — wounds, penicillin in - 199
- Healing, delayed, intraperitoneal chemotherapy and - 57
- Heart, sheep's, extract of, as a growth-promoting substance - 282, 518
- HEATLEY, N. G. : See GARROD, L. P., jt. auth.  
 Heel, painful, abnormality of calcaneus as a cause of - 494  
 Henle, ligament of - 442  
 H.E.P. as a growth-promoting substance - 282
- H.E.P. in wound treatment, further observations of value of - 518  
 Hepatic duct, wound of - 255  
 Hernia(æ), diaphragmatic, in abdomino-thoracic injury - 344  
 — — right retroperitoneal - 421  
 — — traumatic - 391  
 — fascia in repair of - 381  
 — inguinal, new operation - 499  
 — internal, two case reports - 532  
 — Maydl's, case report - 100  
 — obturated, strangulation of ovary and tube in, case report - 539  
 — whole skin-grafts as substitute for fascial sutures - 381
- Herxheimer reaction after penicillin therapy in syphilis - 215  
 Hesselbach, ligament of - 442  
 HIGHT, W. B. : See HOLMES, W., jt. auth.  
 Hip-joint, dislocation of, plasticity following - 355  
 — inflammatory conditions of, plasticity of bone in - 351
- Hispaniola, Island of, origin of syphilis and 228, 229  
 HOLMES, W., HIGHT, W. B., and SEDDON, H. J. : Ischæmic nerve lesions occurring in Volkmann's contracture - 259  
 — — See also SEDDON, H. J., jt. auth.
- Horner's syndrome in Pancoast's superior pulmonary sulcus tumour - 85 et seq.  
 Hospital infection of wounds, control of - 425  
 HOWAT, T. W. : See WILLIAMS, ROBERT, E. O., jt. auth.
- Howship-Romberg sign in obturated hernia - 539  
 von Hütten, Ulrich, on syphilis - 230
- Hunterian Lectures** :—  
 Brailsford, J. F. : Plasticity of bone (April 26, 1944) - 345  
 Gordon-Taylor, Gordon : Second thoughts on the abdominal surgery of 'total' war—a review of over 1300 cases (May 19, 1942) 247  
 Ross, J. Cosbie : Injuries of the urinary bladder (April, 1943) - 44  
 Tubbs, Oswald S. : The effect of ligation on infection of the patent ductus arteriosus (April 28, 1943) - 1
- Hunter's (John) fatal experiment on syphilis - 232  
 Hutchinson's (Jonathan) triad in congenital syphilis - 236  
 Hutchison type of neuroblastoma - 81  
 Hydronephrosis, spontaneous rupture of - 491
- HYMAN, GEOFFREY : A case of pseudarthrosis following fractures of the lumbar transverse processes - 503  
 Hypernephroma, bilateral - 399  
 Hyperparathyroidism, plasticity of bone due to - 348
- ILEUM** and jejunum, diverticulosis of, complications of - 457  
 — tuberculous stricture of, obstruction due to 372, 374  
 — volvulus of, due to Meckel's diverticulum - 510  
 Iliopubic band of Thompson - 442  
 Ilium, plasmocytoma of - 472  
 Immersion injuries in war surgery in R.A.F. - 21
- In Memoriam** :—  
 Sir Cuthbert Wallace, Bart., K.C.M.G., C.B. 329  
 Ernest William Hey Groves - 432  
 India, South, carcinoma of mouth and jaws in - 35  
 Indolent ulcers, envelope treatment of - 31  
 Indolent ulcers, value of a growth-promoting substance in - 281, 518  
 Infantile rickets, plasticity of bone in - 348  
 Infection of wounds, hospital control of - 425  
 Inflammatory lesions of small intestine, stenosis due to cicatrization of - 371

# INDEX

Infra-orbital nerve injury in fractures of zygomatic tripod	296, 299	Law, Colles's	549
Inguinal hernia, new operation	499	Lazar houses	
— ring, internal	441	LEARMONTH, J. R. : An unusual type of arterio-venous communication, case report	233
Internal hernia, two case reports	532	Legg-Perthes' disease, plasticity in	234
Intestinal obstruction due to cicatrization in Crohn's disease	371, 375	Legs, wounds of, in Middle East	321
— — tuberculous stricture of small gut 372 et seq.	58	Leukoplakia, buccal carcinoma and	243
— — intraperitoneal chemotherapy in	101	Ligament of Henle	37
— — with reversed rotation of mid-gut	252	— Hesselbach	442
Intestine ( <i>see also specific portions</i> )		Ligation, carotid, for intracranial aneurysm	442
— double resections of		— effect on infection of patent ductus arteriosus	309
— small, absence of continuity with colon, case report	540	Limbs, plasticity of bones of	352
— — malignant tumours of	481	Lime in tobacco chewing in S. India, buccal carcinoma and	36
— — stenosis of, from cicatrization of isolated inflammatory lesions	371	Lipoma, intrathoracic	451
Intracranial aneurysm, carotid ligation for	309	— an unusually large, case report	324
Intraperitoneal chemotherapy	49	Lips, carcinoma of	37
— injuries of bladder	45 et seq.	— wounds of, in Middle East, plastic repair of	241
Intrathoracic lipoma	451	LITCHFIELD, J. W. : <i>See</i> D'ABREU, A. L., jt. auth.	
Intratracheal anaesthesia in maxillo-facial surgery in Middle East	237	Liver, wounds of	254
Intraventricular foreign body, retained	414	Lock hospitals	235
Intussusception, acute, due to inverted Meckel's diverticulum, case report	328	Lockwood, iter venosum of	361, 362
— due to carcinoma of small gut	482	LONGLAND, C. J., and KESSEL, LIPMANN : Surgery in an airborne division	275
Iodide of potash in syphilis	233	LOVE, McNEILL : A large vesical calculus passed per (female) urethra, case report	323
IRWIN, S. T., and MORISON, J. E. : Congenital cyst of the common bile-duct containing stones and undergoing cancerous change	319	Lumbar transverse processes, fractures of, pseudarthrosis following	503
Ischaemia of peripheral nerves, traumatic	403	Lung, miniature scar-carcinoma of, and upper sulcus tumour of Pancoast	85
Ischaemic contracture, Volkmann's	409	— mixed carcinoma and sarcoma of	454
— damage in peripheral stump of divided nerve	389	Lymphatic glands in buccal carcinoma	38, 39, 40
— nerve lesions in Volkmann's contracture	259	LYTLE, W. J. : The internal inguinal ring	441
de Isla, Ruy Dias, on origin of syphilis	228		
Italy, battle casualty fractures in, penicillin treatment	144	MCDONALD, STUART, jun. : <i>See</i> BINGHAM, J. A. W., jt. auth.	
— gas gangrene in, penicillin in treatment	159	McEWAN, R. J. B., and BICKERTON, J. G. : Battle casualty fractures of the femur, treatment with penicillin	154
Iter venosum of Lockwood	361, 362	McLETCHIE, N. G. B. : Adrenal virilism	90
JAMES, ILLTYD, and PAGEL, WALTER : Miniature scar-carcinoma of the lung and the "upper sulcus tumour" of Pancoast	85	McPHERSON, A. G., and KINMONTH, J. B. : Acute appendicitis and the appendix mass	365
Jaundice after intraperitoneal chemotherapy	54	MAIR, GEORGE B. : Preliminary report on the use of whole skin-grafts as a substitute for fascial sutures in the treatment of herniae	381
Jaws and mouth, carcinoma of, recent advances in treatment	35	Malar fractures in Middle East	242
Jeffrey, J. S. : Application of penicillin to war wounds	124	Malignant tumours ( <i>see</i> Carcinoma ; Sarcoma)	
— — Battle casualty fractures in Italy	144	Mall, pulmonary ridge of	361
— — and THOMSON, SCOTT : Gas gangrene in Italy	159	Mammary prominence, operative replacement of	477
Jejunostomy preliminary to resection and oesophago-gastrostomy	380	Mandible, carcinoma of	38
Jejunum and ileum, diverticulosis of, complications of	457	MARANGOS, GEORGE, and PORTER, G. E. : A ureteric calculus of unusual size	524
JENNINGS, M.A. : <i>See</i> FLOREY, H. W., jt. auth.	373, 375	MASINA, F. H. : <i>See</i> ORR-EWING, JEAN, jt. auth.	
KANTOR, 'string sign' of	371	Maxilla, cancer of	40
KERR, A. B., and WERNER, H. : The clinical value of a growth-promoting substance in the treatment of indolent wounds	281	Maxillary antrum, haemorrhage into, in fractures of zygomatic tripod	296
KESSEL, LIPMANN : <i>See</i> LONGLAND, C. J., jt. auth.	300	Maxillo-facial units in R.A.F. hospitals	23
KEYNES, GEOFFREY : Rupture of the pancreas	508	Maydl's hernia, case report	100
KIDD, H. A. : Suture of laceration of inferior vena cava due to bomb splinter	541	Meckel's diverticulum, inverted, acute intussusception due to, case report	328
Kidney ( <i>see</i> Renal)		— — volvulus of ileum due to	510
KINMONTH, J. B. : <i>See</i> McPHERSON, A. G., jt. auth.		— — war injury of	253
Knife-blade in retropharyngeal space, case report	38	Meningitis due to intrathecal penicillin	115
LARYNGOTOMY in operations for cancer of jaw	465	Menstruation in adrenal virilism	91, 96
Laundry roller gangrene of hand, conservation of metacarpus in		MENZIES, W. C. : <i>See</i> REID, RONALD, jt. auth.	
		Mercury in syphilis, early history of	229 et seq.
		MES, GERRIT M. : A knife-blade in the retro-pharyngeal space, case report	541
		Metacarpus, conservation of, by skin and bone grafting	464
		Metastases with basal-cell carcinoma of face, case report	537
		Middle East, reparative surgery in	237
		Mid-gut, reversed rotation of, and intestinal obstruction, case report	101

- MILES, A. A. : *See* WILLIAMS, ROBERT E. O., jr. auth.
- MITCHELL, ALEXANDER : Dislocation of the cuboid, case report - - - 534
- "Morbus gallicus" - - - 229
- MORGAN, A. D. : *See* NORTHCROFT, G. B., jr. auth.
- C. NAUNTON : Wounds of the colon - 337
- MORISON, J. E. : *See* IRWIN, S. T., jr. auth.
- MORONEY, P. B. : Conservation of the metacarpus by skin and bone grafting in three patients 464
- Morphine in shock - - - 72
- Mortality rate of appendix mass and acute appendicitis cases - - - 368
- statistics in operations for buccal cancer - 42
- MORTON, PAUL C. : *See* CUTLER, ELLIOTT C., jr. auth.
- Mouth and jaws, carcinoma of, recent advances in treatment - - - 35
- wounds of, in Middle East, plastic repair of - 241
- Multiple myelomatosis from plasmocytoma - 473
- MURLEY, R. S. : *See* EVANS, P. R., jr. auth.
- Myelomatosis, multiple, from plasmocytoma - 473
- NAPLES, Siege of, outbreak of syphilis during Nasal wounds in Middle East, plastic surgery in - - - 240
- Nasopharyngeal plasmocytoma - - - 471
- Nasopharynx, cancer of - - - 41
- Neck, wounds of, in Middle East - - - 242
- Nerve(s), divided, ischæmic damage in peripheral stump of - - - 389
- lesions, ischæmic, in Volkmann's contracture - 259
- peripheral, traumatic ischæmia of - - - 403
- Neuroblastoma, adrenal - - - 78
- Neurogenic shock - - - 66
- Neurosurgical Centre, Canadian, at Hackwood Park, Basingstoke, visit to - - - 525
- NICHOLSON, N. J. : Carcinoma of the prostate in a youth, case report - - - 533
- W. F., and STEVENSON, C. R. : Intrapleural penicillin in penetrating wounds of the chest - - - 176
- NORTHCROFT, G. B., and MORGAN, A. D. : A fatal case of traumatic thrombosis of the internal carotid artery - - - 105
- OBSTRUCTIVE appendicitis - - - 468
- Obturator hernia, strangulation of ovary and tube in, case report - - - 539
- Occipital bone, fracture-dislocation of - - - 522
- Œdema in burns - - - 12
- envelope treatment and - - - 26
- gas - - - 166
- Œsophago-gastrostomy, presternal, with removal in carcinoma of œsophagus - - - 394
- and resection in carcinoma of œsophagus - 377
- Œsophagus, carcinoma of, presternal œsophago-gastrostomy and removal - - - 394
- — resection and œsophago-gastrostomy - 377
- OGILVIE, T. A. : Adrenal neuroblastoma - - - 78
- Ointments, penicillin, assay of - - - 122
- OLDFIELD, MICHAEL C. : Some experience of reparative surgery in the Middle East - 237
- Orbital wounds in Middle East, plastic surgery in - 240
- ORR-EWING, JEAN, SCOTT, J. C., MASINA, F. H., TRUETA, J., and GARDNER, A. D. : Local sulphanilamide treatment of fresh wounds in complete plasters - - - 83
- OSBORNE, R. P. : The treatment of burns and wounds with skin loss by the envelope method - - - 24
- Oscillometry in Volkmann's contracture - 271
- Ossification, irregular, effect of - - - 346
- Osteitis deformans, plasticity of bone in - 349
- Osteochondritis, plasticity and - - - 352
- Osteogenesis imperfecta, plasticity of bone in - 347
- Osteomalacia, plasticity of bone in - - - 348
- Osteomyelitis of clavicle - - - 466
- OTTLEY, CONSTANCE M. : Benign papilloma of the ureter, case report - - - 531
- Ovarian dermoids in case of adrenal virilism 92, 96
- Ovary and tube, strangulation of, in obturated hernia, case report - - - 539
- de Oviedo, Gonzalo Fernandez, on origin of syphilis - - - 228
- Oxford unit for standardization of penicillin - 118
- Oxygen therapy in shock - - - 73
- PAGEL, WALTER : *See* JAMES, ILLTYD, jr. auth.
- Paget's disease, plasticity of bone in - - - 349
- Pain due to penicillin injections - - - 115
- in envelope treatment of burns, etc. - - 26
- Painful heel, abnormality of calcaneus as a cause of - - - 494
- Pancoast, upper sulcus tumour of - - - 85
- Pancreas, rupture of - - - 300
- — complete - - - 386
- PANNETT, CHARLES A. : Aseptic anastomosis in gastrectomy - - - 418
- Papilloma of ureter, benign, case report - - - 531
- Para-amino-benzoic acid, sulphonamides and - 50
- Paracelsus on treatment of syphilis - - - 231
- Parachute field ambulance - - - 275
- Paraldehyde per rectum for anæsthesia in buccal carcinoma - - - 38
- Paralysis, facial, due to cholesteatoma of petrous bone - - - 75
- influence of the skeleton - - - 346
- Paraplegia, delayed, following fractures of vertebrae - - - 514
- Paraventricular wounds, penicillin in - - - 204
- PARK, DOUGLAS : Internal hernia, two case reports - - - 532
- PARKES, ATHOL R. : Traumatic ischæmia of peripheral nerves - - - 403
- Patency of iter venosum of Lockwood - - - 362
- Patent ductus arteriosus, effect of ligation on infection of - - - 1
- PATEY, DAVID H., and SCARFF, R. W. : The diagnosis of the depth of skin destruction in burns and its bearing on treatment - - 32
- Pathological fractures with basal-cell carcinoma of face, case report - - - 537
- PAUL, MILROY : Maydl's hernia, case report - 100
- — Stenosis of the small intestine from the cicatrization of isolated inflammatory lesions - - - 371
- Pelvic abscess, intraperitoneal chemotherapy in - 58
- Pelvis, plasticity of - - - 352
- Penicillin, absorption and excretion of - - - 113
- administration and dosage - - - 114
- antibacterial action - - - 112
- application to war wounds - - - 124
- army progress with - - - 110
- assay, methods - - - 119
- — of pharmaceutical preparations - - - 122
- assessment of progress and duration of treatment - - - 116
- bacterial examination of wounds treated with - 129
- — methods in connexion with treatment - 117
- in battle casualty fractures in Italy - - - 144
- in blood, assay of - - - 123
- body fluids, assay of - - - 122
- to control infection in open fractures of femur - - - 147
- dispensing of - - - 112
- in early closure of soft tissue wounds, comparison with sulphanilamide - - - 140
- and early secondary suture in flesh wounds - 132
- editorial - - - 109

- Penicillin in gas gangrene in Italy - - - 159  
 — general indications for - - - 124  
 — in gonorrhoea - - - 211  
 — head and spinal wounds - - - 199  
 — indications for local therapy - - - 125  
 — — systemic therapy - - - 125  
 — intrapleurally in penetrating wounds of chest - - - 176  
 — limitations of - - - 128  
 — misuses of - - - 128  
 — potency - - - 113  
 — principles of treatment - - - 112  
 — properties of - - - 112  
 — prophylactically in wounds of aerial warfare - - - 207  
 — stability of - - - 112  
 — standardization of potency in Oxford units - - - 118  
 — in syphilis - - - 214  
 — toxicity and reactions - - - 115  
 — in war surgery in R.A.F. - - - 18  
 — — wounds of chest - - - 179  
 Penicillinase - - - 118  
*Penicillium notatum* - - - 112  
 PENNYBACKER, JOE: Cholesteatoma of the petrous bone - - - 75  
 Pepper type of neuroblastoma - - - 81  
 Peptic ulcer, perforated, intraperitoneal chemotherapy in - - - 58  
 Perabrodil injection into muscle in study of Volkmann's contracture - - - 259  
 Pericardium, congenital deficiency of, associated with bronchogenic cyst - - - 357  
 — embryology - - - 360  
 Peripheral nerves, traumatic ischaemia of - - - 403  
 Peritoneal lining membrane, absorption of intraperitoneal substances by - - - 50  
 Peritonitis in diverticulitis from acquired diverticulosis - - - 458 et seq.  
 — intraperitoneal chemotherapy - - - 49  
 — with appendicitis - - - 366, 367  
 Perspex splint in fracture-dislocation of occipital bone - - - 522  
 Petrous bone, cholesteatoma of - - - 75  
 PHILIP, J. F.: See FOWLER, A., jt. auth.  
 PILLSBURY, D. M.: See WISE, C. R., jt. auth.  
 Pituitary basophilism (Cushing's syndrome) - - - 97  
 Plasma basket for dropping by parachute - - - 280  
 — transfusion in shock - - - 72, 73  
 — — war surgery in R.A.F. - - - 18  
 Plasmocytoma of bone - - - 471  
 Plaster treatment of wounds, local sulphanilamide in treatment - - - 83  
 Plastic operations after surgical removal in buccal carcinoma - - - 42  
 — surgery in Middle East - - - 237  
 Plasticity of bone - - - 345  
 Pleural infections in war wounds, penicillin in - - - 181  
 POLLOCK, GEORGE A.: A conservative operation for severe hand injury, case report - - - 535  
 Polyblastoma of small intestine - - - 483  
 Polycytoma of small intestine - - - 483  
 Polyostotic fibrous dysplasia, plasticity of bone in - - - 350  
 POOLE, L. T.: Army progress with penicillin - - - 110  
 PORTER, G. E.: See MARANGOS, GEORGE, jt. auth.  
 Potassium iodide in syphilis - - - 233  
 Powders, penicillin - - - 115  
 — — assay of - - - 122  
 Prepericardial cyst - - - 447  
 Pressure beneath deep fascia in aetiology of ischaemia of peripheral nerves - - - 410  
 Primary peritonitis, intraperitoneal chemotherapy in - - - 57  
 Proptosis due to adrenal neuroblastoma - - - 79, 82  
 Prostate, carcinoma of, in a youth, case report - - - 533  
 Pseudarthrosis following fractures of lumbar transverse processes - - - 503  
 — of metacarpals, conservative operation in - - - 465  
 Pulmonary ridge of Mall - - - 361  
 Pulse in Volkmann's contracture - - - 271  
 Pulse-rate in shock - - - 69  
 Punch actinomycosis - - - 506  
 Pyothorax in war wounds, penicillin in - - - 181
- ## RADIOGRAPHY in adrenal neuroblastoma - 82
- bilateral renal carcinoma - - - 400  
 — bladder injuries - - - 46  
 — cholesteatoma of petrous bone - - - 75, 76, 77  
 — diaphragmatic hernia - - - 392, 393, 422, 423, 424  
 — dislocation of cuboid - - - 534  
 — fractures of zygomatic tripod - - - 289 et seq., 296  
 — intestinal obstruction due to scarring from inflammatory lesions - - - 371  
 — intracranial aneurysm - - - 309  
 — knife-blade in retropharyngeal space - - - 541  
 — Legg-Perthes' disease - - - 353  
 — malignant tumours of small intestine - - - 480  
 — osteomyelitis of clavicle - - - 467  
 — plasmocytoma - - - 472, 474  
 — plasticity of bone - - - 345  
 — pseudarthrosis following fractures of lumbar transverse processes - - - 503, 505  
 — punch actinomycosis - - - 506  
 — repair of acromio-clavicular dislocation - - - 104  
 — retained intraventricular foreign body - - - 414  
 — retrocalcaneal bursitis - - - 495  
 — reverse spondylolisthesis - - - 536  
 — reversed rotation of mid-gut - - - 103  
 — ulcer of second part of duodenum - - - 501, 502  
 — unusual thoracic tumours - - - 447, 452, 455, 456  
 — ureteric calculus - - - 525  
 Radiotherapy in adrenal neuroblastoma - - - 83  
 Radium therapy in buccal carcinoma - - - 37 et seq.
- ## Rare or Obscure Cases:—
- Acute intussusception due to inverted Meckel's diverticulum - - - 328  
 Basal-cell carcinoma of face, with remote metastases and pathological fractures - - - 537  
 Carcinoma of the prostate in a youth - - - 533  
 A case of benign papilloma of the ureter - - - 531  
 A case of intramural abscess of the colon - - - 325  
 A case of reversed rotation of the mid-gut and intestinal obstruction - - - 101  
 A case of rupture of a congenital discoid cartilage - - - 435  
 Congenital absence of continuity between small and large intestine, with abnormal blood-supply of the proximal colon - - - 540  
 A conservative operation for severe hand injury - - - 535  
 A curious case of air embolism - - - 433  
 Dislocation of the cuboid - - - 534  
 Duodenal diverticulum secondary to a gastric ulcer - - - 434  
 A fatal case of traumatic thrombosis of the internal carotid artery - - - 105  
 A filarial nodule simulating a cyst of the external semilunar cartilage - - - 326  
 Foreign-body cyst of triceps muscle - - - 327  
 A knife-blade in the retropharyngeal space - - - 541  
 A large vesical calculus passed per (female) urethram - - - 323  
 Maydl's hernia - - - 100  
 The result of operative repair of severe acromio-clavicular dislocation - - - 103  
 Reverse spondylolisthesis - - - 536  
 Strangulation of the ovary and Fallopian tube in an obturated hernia - - - 539  
 Two cases of internal hernia - - - 532  
 An unusual type of arteriovenous communication - - - 321  
 An unusually large lipoma - - - 324  
 Reaction, Herxheimer, after penicillin therapy in syphilis - - - 215

- Regional enteritis in childhood - - - 512  
 — — stenosis due to - - - 371, 375  
 Rehabilitation centres for R.A.F. air-crews - - - 23  
 REID, HUGH : A case of traumatic diaphragmatic  
 hernia - - - 391  
 — RONALD, and MENZIES, W. C. : Spontaneous  
 rupture of a hydronephrosis - - - 491  
 Renal adenoma, malignant transformation in - - - 315  
 — carcinoma, bilateral - - - 399  
 — fibrosis, rickets associated with, plasticity of  
 bone in - - - 348  
 Resuscitation in war surgery in R.A.F. - - - 18  
 — wounds of colon - - - 341  
 Retrocalcaneal bursitis - - - 494  
 Retroperitoneal diaphragmatic hernia, right - - - 421  
 Retropharyngeal space, knife-blade in, case report - - - 541  
 Reverse spondylolisthesis, case report - - - 536  
 Reviews of Books (Titles) :—  
   *Aids to theatre technique* (M. Houghton and  
   M. Harding) - - - 439  
   *The American Academy of Orthopaedic Sur-  
   geons presents lectures on reconstruction  
   surgery* (ed. J. E. M. Thomson) - - - 543  
   *An atlas of anatomy* (J. C. Boileau Grant) - - - 334  
   *Demonstrations of physical signs in clinical  
   surgery* (H. Bailey) - - - 333  
   *The diseases of the endocrine glands* (H.  
   Zondek, trans. C. P. Giles) - - - 333  
   *Emergency surgery* (H. Bailey) - - - 107  
   *Endocrine man* (L. R. Broster) - - - 335  
   *The essentials of modern surgery* (ed. R. M.  
   Handfield-Jones and R. E. Porritt) - - - 332  
   *A field surgery pocket book* (various authors) - - - 333  
   *Fracture of the jaws and other facial bones*  
   (G. Major) - - - 107  
   *Gas and air analgesia* (R. J. Minnitt) - - - 331  
   *The hospital care of the surgical patient*  
   (G. Crile, jun., and F. L. Shively, jun.) - - - 334  
   *Illustrations of regional anatomy* (E. B.  
   Jamieson) - - - 331  
   *Medical clinics on bone diseases* (I. Snapper) - - - 108  
   *Modern operative surgery* (ed. G. G. Turner) - - - 335  
   *The 1943 year book of industrial and ortho-  
   paedic surgery* (ed. C. F. Painter) - - - 334  
   *Notable names in medicine and surgery* (H.  
   Bailey and W. J. Bishop) - - - 542  
   *Pye's surgical handicraft* (ed. H. Bailey) - - - 439  
   *Operations of general surgery* (T. G. Orr) - - - 543  
   *Orthopaedic surgery* (W. Mercer) - - - 108  
   *The radiology of bones and joints* (J. F.  
   Brailsford) - - - 335  
   *Recent advances in anaesthesia and analgesia*  
   (C. L. Hewer) - - - 437  
   *Regional analgesia* (H. W. L. Molesworth) - - - 336  
   *The rehabilitation of the injured* (J. H. C. Colson) - - - 439  
   *Studies of burns and scalds* (reports of Burns  
   Unit, Royal Infirmary, Glasgow) - - - 543  
   *The surgery of abdominal trauma* (G. E. Parker) - - - 437  
   *Surgery of modern warfare* (ed. H. Bailey) - - - 331  
   *Textbook of anaesthetics* (R. J. Minnitt and  
   J. Gillies) - - - 543  
   *Textbook of surgical treatment* (ed. C. F. W.  
   Illingworth) - - - 439  
   *The urinary tract* (H. D. Kerr and C. L. Gillies) - - - 542  
   *Varicose veins, haemorrhoids, and other condi-  
   tions* (R. W. Foote) - - - 331  
   *Vascular responses in the extremities of man  
   in health and disease* (D. I. Abramson) - - - 438  
   *X-ray examination of the stomach* (F. E.  
   Templeton) - - - 542  
 Reviews of Books (Authors) :—  
   Abramson, D. I. : *Vascular responses in the  
   extremities of man in health and disease* - - - 438  
   Bailey, H. : *Demonstrations of physical signs  
   in clinical surgery* - - - 333  
   Bailey, H. : *Emergency surgery* - - - 107  
   Bailey, H. : *Pye's surgical handicraft* (ed.) - - - 439  
   Bailey, H. : *Surgery of modern warfare* (ed.) - - - 331  
   Bailey, H., and Bishop, W. J. : *Notable names  
   in medicine and surgery* - - - 542  
   Bishop, W. J. : See Bailey, H., jt. auth.  
   Brailsford, J. F. : *The radiology of bones and  
   joints* - - - 335  
   Broster, L. R. : *Endocrine man* - - - 335  
   Colson, J. H. C. : *The rehabilitation of the  
   injured* - - - 439  
   Crile, G., jun., and Shively, F. L., jun. :  
   *The hospital care of the surgical patient* - - - 334  
   Foote, R. W. : *Varicose veins, haemorrhoids,  
   and other conditions* - - - 331  
   Giles, C. P. : *The diseases of the endocrine  
   glands* (H. Zondek) (trans.) - - - 333  
   Gillies, C. L. : See Kerr, H. D., jt. auth.  
   Gillies, J. : See Minnitt, R. J., jt. auth.  
   Grant, J. C. B. : *An atlas of anatomy* - - - 334  
   Handfield-Jones, R. M., and Porritt, A. E. :  
   *The essentials of modern surgery* (ed.) - - - 332  
   Harding, M. : See Houghton, M., jt. auth.  
   Hewer, C. L. : *Recent advances in anaesthesia  
   and analgesia* - - - 437  
   Houghton, M., and Harding, M. : *Aids to  
   theatre technique* - - - 439  
   Illingworth, C. F. W. : *Textbook of surgical  
   treatment* (ed.) - - - 439  
   Jamieson, E. B. : *Illustrations of regional  
   anatomy* - - - 331  
   Kerr, H. D., and Gillies, C. L. : *The urinary  
   tract* - - - 542  
   Major, G. : *Fracture of the jaws and other  
   facial bones* - - - 107  
   Mercer, W. : *Orthopaedic surgery* - - - 108  
   Minnitt, R. J. : *Gas and air analgesia* - - - 331  
   Minnitt, R. J., and Gillies, J. : *Textbook of  
   anaesthetics* - - - 543  
   Molesworth, H. W. L. : *Regional analgesia* - - - 336  
   Orr, T. G. : *Operations of general surgery* - - - 543  
   Painter, C. F. : *The 1943 year book of indus-  
   trial and orthopaedic surgery* (ed.) - - - 334  
   Parker, G. E. : *The surgery of abdominal  
   trauma* - - - 437  
   Porritt, A. E. : See Handfield-Jones, R. M.,  
   jt. ed.  
   Shively, F. L., jun. : See Crile, G., jun.,  
   jt. auth.  
   Snapper, I. : *Medical clinics on bone diseases* - - - 108  
   Templeton, F. E. : *X-ray examination of  
   the stomach* - - - 542  
   Thomson, J. E. M. : *The American Academy  
   of Orthopaedic Surgeons presents lectures  
   on reconstruction surgery* (ed.) - - - 543  
   Turner, G. G. : *Modern operative surgery* (ed.) - - - 335  
   Zondek, H. : *The diseases of the endocrine  
   glands* (trans. C. P. Giles) - - - 333  
   Rickets, infantile, plasticity of bone in - - - 348  
   Ricord, Philippe, on venereal disease - - - 233  
   Riffler, dental, in operation for retrocalcaneal  
   bursitis - - - 497  
   ROBERTS, J. GUNN : Foreign-body cyst of triceps  
   muscle, case report - - - 327  
   ROBINSON, JOHN N. : Penicillin therapy in gonor-  
   rhoea - - - 211  
   ROGERS, LAMBERT : Carotid ligation for intra-  
   cranial aneurysm - - - 309  
   — — Delayed paraplegia following fractures of  
   of the vertebrae - - - 514  
   ROSS, J. COSBIE : Injuries of the urinary bladder - - - 44  
   Rotation, reversed, of mid-gut and intestinal  
   obstruction, case report - - - 101  
   Royal Air Force, war surgery in - - - 12  
   Rupture of bladder - - - 44

- Rupture of congenital discoid cartilage, case report 435  
 — of jejunal diverticulum due to trauma - 463  
 — pancreas - - - - - 300  
 — complete - - - - - 386  
 — spontaneous, of a hydronephrosis - 491  
 RUSBY, N. LLOYD, and SELLORS, T. HOLMES: Congenital deficiency of the pericardium associated with a bronchogenic cyst - 357
- ST. THOMAS'S Hospital appendicitis statistics - 368  
 Salt intake in treatment of burns in Middle East 244  
 SANDUSKY, WILLIAM R.: See CUTLER, ELLIOTT C., jt. auth.
- Sarcoma and carcinoma of lung, mixed - 454  
 — Ewing's, diagnosis from adrenal neuroblastoma 82  
 — of small intestine - - - - - 482  
 Sarsaparilla in syphilis - - - - - 231  
 Scapula and clavicle, fascial sling for, in dropped shoulder and winged scapula - 311  
 — winged, fascial sling for - - - - - 311  
 Scar-carcinoma, miniature, of the lung, and the "upper sulcus tumour" of Pancoast - 85  
 SCARFF, R. W.: See PATEY, DAVID H., jt. auth.
- Scoliosis due to exanthemata - - - - - 346  
 — trauma - - - - - 352  
 SCOTT, J. C.: See ORR-EWING, JEAN, jt. auth.
- SEDDON, H. J., and HOLMES, W.: Ischaemic damage in the peripheral stump of a divided nerve - - - - - 389  
 — — See also HOLMES, W., jt. auth.
- SELLORS, T. HOLMES: See RUSBY, N. LLOYD, jt. auth.
- Semilunar cartilage, external, cyst of, filarial nodule simulating, case report - 326  
 Sensory loss in limb injuries with nerve lesions 403 et seq.
- Sepsis in wounds in Middle East - - - - - 245  
 Serratus anterior palsy, fascial sling for scapula in 311  
 Sex incidence of appendicitis - - - - - 366  
 — malignant tumours of small intestine - 479  
 Sexual changes in adrenal virilism - - - - - 91  
 Sheep's heart extract as a growth-promoting substance - - - - - 282, 518
- Shock in bladder injuries - - - - - 46  
 — capillary injury and - - - - - 70  
 — a consideration of its nature and treatment - 66  
 — definition and classification - - - - - 66  
 — diagnosis of - - - - - 71  
 — haemorrhage and - - - - - 68  
 — pulse and blood-pressure in - - - - - 69  
 Shoulder, dropped, fascial sling for - - - - - 311  
 Sick quarters at R.A.F. stations - - - - - 22  
 Sign, Howship-Romberg, in obturated hernia - 539  
 — 'string', of Kantor - - - - - 371
- SINGER, ALEC: Basal-cell carcinoma of face, with remote metastases and pathological fractures, case report - 537  
 Site incidence of cancer of small intestine - 481  
 — epithelioma of mouth - - - - - 36  
 — plasmocytoma - - - - - 475  
 — wounds of colon - - - - - 338  
 Skeletal changes due to paralysis - - - - - 346
- Skin, blueness of, after intraperitoneal chemotherapy - - - - - 54  
 — destruction in burns, diagnosis of depth of - 32  
 — loss of, in burns and wounds, treatment by envelope method - - - - - 24  
 — temperatures in Volkmann's contracture - 272  
 Skin-grafting in burns - - - - - 15  
 — conservation of metacarpus - - - - - 464  
 — during envelope treatment of burns - - 27  
 — H.E.P. in - - - - - 284  
 Skin-grafts, whole, as substitute for fascial sutures in herniae - - - - - 381
- Skull, plasticity of bones of - - - - - 351  
 SMALL, J. M.: Retained intraventricular foreign body - - - - - 414  
*Smilax sinensis* in syphilis - - - - - 231  
 SMITH, RODNEY: Volvulus of the small intestine due to a Meckel's diverticulum - 510  
 Snuffs, penicillin, assay of - - - - - 122  
 Sodium hypochlorite in envelope treatment of burns, etc. - - - - - 26
- SOMERVELL, T. H.: Recent advances in the treatment of carcinoma of the mouth and jaws 35  
 Southern India, carcinoma of mouth and jaws in 'Spanish disease' - - - - - 227  
 Spasm in causation of obstructive appendicitis - 468  
 Spinal accessory palsy, fascial sling for scapula and clavicle in - - - - - 311  
 — wounds, penicillin in - - - - - 199  
 Spine, plasticity of bones of - - - - - 346, 351  
 Splint, Perspex, in fracture-dislocation of occipital bone - - - - - 522  
 Spondylolisthesis, reverse, case report - - 536  
 Spontaneous rupture of a hydronephrosis - 491  
 'Spring water cysts' of mediastinum - - 449  
 Stains to differentiate depth of skin destruction in burns - - - - - 35
- Stannard (see also Bunyan-Stannard)  
 — glove in burns in R.A.F. - - - - - 13  
*Staph. aureus* in early unsutured war wounds - 129  
 — wound infections, hospital control of - 425  
 Stenosis as cause of obstructive appendicitis - 468  
 — of small intestine from cicatrization of isolated inflammatory lesions - - - - - 371
- Stercolith in causation of obstructive appendicitis 468  
 Sterilization of envelopes in treatment of burns, etc. 25  
 STEVENSON, C. R.: See NICHOLSON, W. F., jt. auth.
- STOCK, FRANCIS E.: A case of intramural abscess of the colon - - - - - 325  
 Strangulation of ovary and tube in obturated hernia, case report - - - - - 539  
 Streptococcus, haemolytic, in chronic septic war wounds - - - - - 129  
 — *pyogenes* in wound infection, hospital control of 425  
 Stretcher, collapsible airborne pattern - - 280  
 Stricture of small intestine, tuberculous obstruction due to - - - - - 372 et seq.
- 'String sign' of Kantor - - - - - 371  
 Subacute bacterial endarteritis complicating patent ductus arteriosus - - - - - 2  
 SUGGIT, STEPHEN C.: See UNGLEY, H. GORDON, jt. auth.
- Sulphadiazine in intraperitoneal chemotherapy 51 et seq.  
 Sulphanilamide in early closure of soft tissue wounds, comparison with penicillin - 140  
 — intraperitoneal chemotherapy - 50 et seq.  
 — local treatment of fresh wounds in complete plasters - - - - - 83
- Sulphapyridine in intraperitoneal chemotherapy 51 et seq.  
 Sulphathiazole in intraperitoneal chemotherapy 51 et seq.
- Sulphonamide-resistant gonorrhoea, penicillin in 211  
 Sulphonamides in war surgery in R.A.F. 13, 18, 19  
 — with penicillin in head and spinal wounds - 205  
 — in wounds of colon - - - - - 344  
 Surgery in an airborne division - - - - - 275  
 Suture, early secondary, and penicillin in flesh wounds - - - - - 132  
 — of laceration of inferior vena cava due to bomb splinter - - - - - 508  
 — wounds in battle-casualty fractures in Italy - 146  
 Sweat secretion in study of Volkmann's contracture 259  
 Syndrome, Cushing's - - - - - 97  
 — Horner's, in Pancoast's superior pulmonary sulcus tumour - - - - - 85 et seq.



- Syphilis, the early history of - - - 226  
 — penicillin therapy in - - - 214  
 Syphilization - - - 234
- T**ABES dorsalis, plasticity of bone in - - - 355  
 TAYLOR, HERMAN: An operation for removal of carcinoma of the œsophagus with presteral œsophago-gastrostomy - - - 394  
 — SELWYN: Fracture-dislocation of the occipital bone - - - 522  
 Teeth extraction in cancer of jaws - - - 38  
 Temperature changes due to penicillin administration - - - 115  
 — skin, in Volkmann's contracture - - - 272  
 Temporal route for elevation in fractures of zygomatic tripod - - - 297  
 TENNENT, WILLIAM: Plasmocytoma of bone - - - 471  
 Thompson, iliopubic band of - - - 442  
 THOMPSON, VERNON C.: Carcinoma of the œsophagus, resection and œsophago-gastrostomy - - - 377  
 THOMSON, SCOTT: The bacteriological examination of wounds treated with penicillin - - - 129  
 — — See also D'ABREU, A. L., jt. auth.  
 — — See also JEFFREY, J. S., jt. auth.  
 Thoracic (see Chest)  
 Thrombophlebitis due to penicillin injections - - - 115  
 Thrombosis, traumatic, of internal carotid, case report - - - 105  
 Tingling in envelope treatment of burns, etc. - - - 26  
 Tobacco chewing in S. India, buccal carcinoma and - - - 36  
 Tongue, carcinoma of - - - 39  
 Tonsil, cancer of - - - 40, 41  
 Toxæmia in shock - - - 71  
 Transthoracic route for resection and œsophago-gastrostomy - - - 377  
 Trauma, localized plasticity of bone due to - - - 352  
 Traumatic diaphragmatic hernia - - - 391  
 — ischæmia of peripheral nerves - - - 403  
 — rupture of jejunal diverticulum - - - 463  
 — thrombosis of internal carotid, case report - - - 105  
 Triceps muscle, foreign-body cyst of, case report - - - 327  
 TRUETA, J.: See ORR-EWING, JEAN, jt. auth.  
 Trunk, wounds of, in Middle East - - - 243  
 TUBBS, OSWALD S.: The effect of ligation on infection of the patent ductus arteriosus - - - 1  
 Tuberculous stricture of small intestine, obstruction due to - - - 372 et seq.  
 Tumour(s) (see also Cancer; etc.)  
 — superior pulmonary sulcus, Pancoast's - - - 85  
 — thoracic, unusual - - - 447  
 — Wilm's, diagnosis from adrenal neuroblastoma - - - 82  
 Turbidimetric methods of assay of penicillin - - - 119
- U**LCERS, chronic, H.E.P. in treatment of - - - 519  
 — gastric, duodenal diverticulum secondary to, case report - - - 434  
 — — gastroscopic control of duodenal feeding in - - - 303  
 — indolent, envelope treatment of - - - 31  
 — peptic, perforated, intraperitoneal chemotherapy in - - - 58  
 — of second part of duodenum - - - 500  
 Umbilical graft for replacement of mammary prominence - - - 477  
 UNGLEY, H. GORDON, and SUGGITT, STEPHEN C.: Fractures of the zygomatic tripod - - - 287  
 Unguentum saracenum in syphilis - - - 230  
 Ureter, benign papilloma of, case report - - - 531  
 Ureteric calculus of unusual size - - - 524  
 Urethra, female, large vesical calculus passed via, case report - - - 323  
 Urticaria, generalized, due to penicillin - - - 115
- V**AN GIESON'S stain, modification to differentiate depth of skin destruction in burns - - - 31  
 VAN MEURS, D. P.: Strangulation of the ovary and Fallopian tube in an obturated hernia, case report - - - 535  
 Vasogenic shock - - - 66, 67  
 Vena cava, inferior, suture of laceration due to bomb splinter - - - 508  
 Ventricular wounds, penicillin in - - - 202  
 Vertebrae, fractures of, delayed paraplegia after - - - 512  
 — lumbar, fracture of transverse processes, pseudarthrosis following - - - 502  
 Vesical (see Bladder)  
 Vicary Lecture:—  
 Abraham, J. Johnston: The early history of syphilis (April 13, 1944) - - - 225  
 Vicary, Thomas - - - 224  
 Virilism, adrenal - - - 90  
 Visits to War Clinics:—  
 The Canadian Neurosurgical Centre, Hackwood Park, Basingstoke - - - 525  
 Vitamin A deficiency, buccal carcinoma and - - - 36  
 Volkmann's contracture - - - 409  
 — — ischæmic nerve lesions in - - - 256  
 Volvulus associated with diverticula of small intestine - - - 463  
 — of ileum, due to Meckel's diverticulum - - - 510
- W**ALKER, R. MILNES: The complications of acquired diverticulosis of the jejunum and ileum - - - 457  
 — — Duodenal diverticulum secondary to a gastric ulcer, case report - - - 434  
 Wallace, Sir Cuthbert, Bart., K.C.M.G., C.B.: In memoriam - - - 329  
 — William, on treatment of syphilis - - - 233  
 War, battle casualty fractures of femur treated with penicillin - - - 154  
 — fractures in Italy, penicillin in treatment - - - 144  
 — surgery in the Royal Air Force - - - 12  
 — — organization of surgical services - - - 22  
 — wounds (see Wounds)  
 WERNER, H.: Further observations of the clinical value of a growth-promoting substance in wound treatment - - - 518  
 — — See also KERR, A. B., jt. auth.  
 WILLIAMS, ROBERT E. O., CLAYTON-COOPER, BARBARA, HOWAT, T. W., and MILES, A. A.: The control of hospital infection of wounds - - - 425  
 Wilm's tumour, diagnosis from adrenal neuroblastoma - - - 82  
 Winged scapula, fascial sling for - - - 311  
 WISE, C. R., and PILLSBURY, D. M.: Penicillin therapy in syphilis - - - 214  
 Wounds (see also under various organs)  
 — bacteriological examination after penicillin - - - 129  
 — due to action in R.A.F. - - - 15  
 — flesh, early secondary suture and penicillin in - - - 132  
 — H.E.P. in treatment of - - - 281, 518  
 — indolent, value of a growth-promoting substance in - - - 281, 518  
 — infection of, hospital control of - - - 425  
 — local sulphanilamide treatment in complete plasters - - - 83  
 — in Middle East, plastic surgery in - - - 238  
 — penicillin in - - - 124  
 — soft tissue, early closure with chemotherapy - - - 140  
 — with skin loss and burns, treatment by envelope method - - - 24
- X**-RAY therapy in buccal carcinoma - - - 42  
**Z**YGOMATIC tripod, fractures of - - - 287

